LOAN DOCUMENT

PHOTOGRAPH THIS SHEET

DTIC ACCESSION NUMBER

LEVEL

INVENTORY

DOCUMENT IDENTIFICATION

DISTRIBUTION STATEMENT

HANDLE WITH CARE

ACCESSION FOR

NTIS GRA&I
DTIC TRAC
UNANNOUNCED
JUSTIFICATION

BY

DISTRIBUTION/

AVAILABILITY CODES

DISTRIBUTION	AVAILABILITY AND/OR SPECIAL	
A-1		

DISTRIBUTION STAMP

DATE ACCESSIONED

Reproduced From
Best Available Copy

DATE RETURNED

19981223 009

DATE RECEIVED IN DTIC

REGISTERED OR CERTIFIED NUMBER

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-FDAC

DTIC FORM JUN 90 70A

DOCUMENT PROCESSING SHEET

PREVIOUS EDITIONS MAY BE USED UNTIL STOCK IS EXHAUSTED.

LOAN DOCUMENT

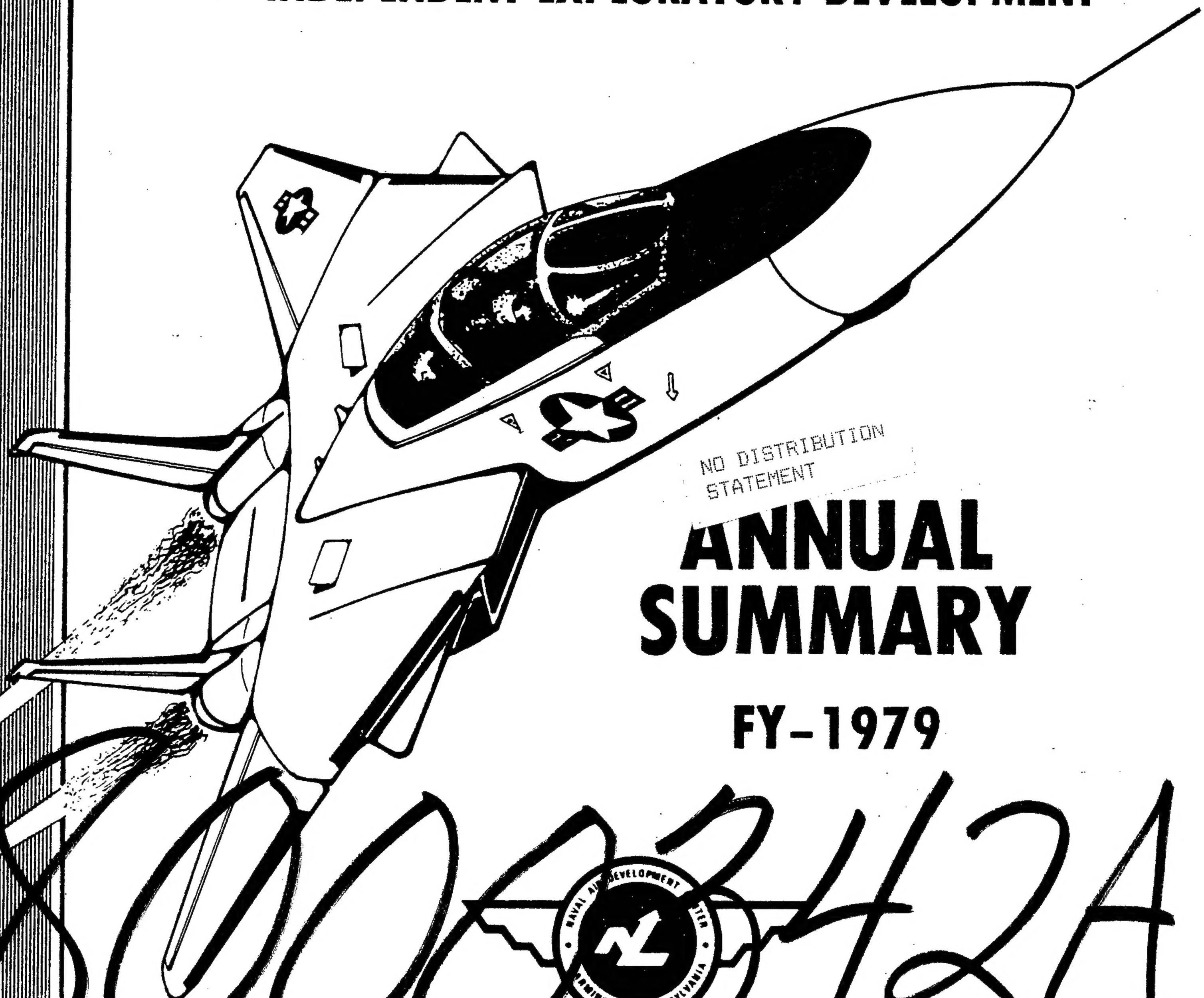
5-13-80

REPORT CONTROL SYMBOL NAVMAT 3920.1

NADC

INDEPENDENT RESEARCH Tech. Info!

INDEPENDENT EXPLORATORY DEVELOPMENT



NO DISTRIBUTION STATEMENT

ANNUAL SUMMARY

FY-1979

800342A

NAVAL AIR DEVELOPMENT CENTER

WARMINSTER, PA 18974

FOREWORD

The Independent Research (IR) Program and the Independent Exploratory Development (IED) Program, under the auspices of the Chief of Naval Material, were instituted to stimulate original work or enhance competence in all fields of science and technology associated with aerospace components and systems. They implement the Navy's general policy that research and development activities devote a portion of their R&D capacity to the exploitation of new ideas conceived in-house and considered of value to their general field of interest.

The IR/IED programs include:

1. a stimulating research and development atmosphere conducive to the formation of innovative concepts and ideas;

2. continuing programs of research to establish a reservoir of knowledge that can be drawn upon for the solution of immediate and long-term naval air problems;

3. opportunities for preliminary investigation of the more speculative problems unsuitable for specific task assignment.

4. a flexibility of study that will enable programs to be started or stopped as deemed appropriate by NAVAIRDEVCEN; and

5. encouragement of creative initiative which attracts competent researchers.

The annual report on the Independent Research and Independent Exploratory Development Programs at the Naval Air Development Center was prepared in reply to NAVMATINST 3920.3B of 12 June 1972.

R. Kenneth Lobb

R. KENNETH LOBB
Technical Director

THIS PAGE LEFT BLANK INTENTIONALLY

TABLE OF CONTENTS

SECTION I

ARTICLES

RESEARCH ON MULTI-PURPOSE CORROSION INHIBITORS FOR AEROSPACE MATERIALS IN NAVAL ENVIRONMENTS

Task No. ZR02208
IR Work Unit No. GC105

By V. S. Agarwala

A study to "tailor make" corrosion inhibitor systems for the control of common aircraft corrosion and corrosion assisted failures has been conducted. The mechanisms of principal driving corrosion processes and control are considered to devise new multi-purpose inhibitor systems which can protect high strength structural alloys from catastrophic failures such as stress corrosion cracking, corrosion fatigue, hydrogen embrittlement, exfoliation, and wear.

BACKGROUND

Corrosion damages in naval aircraft range from simple general corrosion to complete failure of structural parts much below their design strength level. According to new estimates (National Bureau of Standards and 3M data) the Navy spends nearly $450 million dollars annually in corrosion costs on aircraft alone. Based on failure reports from the fleet, the major corrosion damages appear in the form of structural breakdown such as exfoliation, stress corrosion cracking, corrosion fatigue or hydrogen embrittlement. They mostly originate from pitting and/or crevice corrosion type of attack. These are generally caused by imperfections in the structure or porosity and breakdown in the protective films and coatings. Since paints and finishes used for this purpose are only temporary barriers to the environment, they are likely to break down easily and provide active centers for more accelerated attack of the underlying metal. Thus, the presence of a corrosion inhibitor in the system is essential to provide corrosion protection to the underlying metal.

In an earlier study[1] it was determined that the mechanisms involved in various corrosion failures have some basic common factors as the governing rules of the process. Principally they are classified as follows:

1. Anodic dissolution of metal

   $M \qquad M^{+n} + ne^-$

2. Cathodic reduction of hydrogen

   $H^+ + e \qquad$ H atomic $\qquad 1/2\ H_2$

   H atomic $\qquad$ H adsorbed $\qquad$ H absorbed (Metal)

3. Breakdown of passivity (auto catalytic)

   $M^+ + H_2O \qquad M.OH + H^+$

   $M.O + 2H^+ \quad Cl \quad M^+ + H_2O$

4. Plastic deformation (mechanical and metallurgical)

   Emergence of Slip Steps $\qquad$ New Active Surfaces

Among these reactions, reaction 2 is probably the most critical in causing structural damages. Since all of the above reactions are of an electro-chemical nature, they can be mechanistically controlled by chemicals; i.e., by utilizing the selective reduction-oxidation (redox) properties of certain inorganic compounds. Currently a number of inorganic compounds are known which can be classified as corrosion inhibitors. They mostly control either anodic or cathodic reactions. However, as corrosion failures result from a combination of several of the above reactions, a single inorganic compound will be unable to perform a multi-functional task. Thus, a combination of several different redox systems is most essential for the effective control of corrosion and corrosion assisted failures.

1. *Agarwala, V. S.; "Accelerated Environmental Testing of Aerospace Materials for the Study of Stress Corrosion Cracking and Hydrogen Embrittlement"; Oct. 1977, NRC Senior Associateship Report, Nat. Acad. Sci., Washington, D.C.*

OBJECTIVES

The objective of IRGC105 is to analyze the mechanisms of corrosion and corrosion assisted failures with a view to devising new multi-purpose versatile inhibitors or inhibitor systems which can protect high-strength structural alloys from catastrophic failures such as stress corrosion cracking, corrosion fatigue, hydrogen or environmental embrittlement, exfoliation and wear. It is also anticipated that this research will provide meaningful data, test results and methods which can be used to produce a product or procedure that can be of immediate application to naval aircraft.

PROGRESS

Selection and determinations of inorganic compounds as functional corrosion inhibitors and their formulation into one versatile inhibitor system are the key elements of this program. A rapid electrochemical technique was, therefore, required to perform the screening and selection process. Earlier[2] a technique was developed by which inorganic compounds could be linked with a quaternary ammonium salt by an anion exchange reaction, which makes them soluble in many organic solvents. Use of this method, thus, reduces the difficulty of retaining the redox functional properties of the additives compounded in the formulation (mixture) without encountering interference. In another program[3], it was also established that inorganic compounds dissolved in organic solvents were much more efficient and long lasting as inhibitors than their counterpart in aqueous phase.

The electrochemical method developed for inhibitor selection was a galvanic corrosion monitor probe as shown in figure 1. The probe works on the principles of a galvanic cell and is comprised of a series of plates of two different metals (steel and copper) sandwiched together alternately separated by an electrical insulator and encapsulated in epoxy. An electronic zero-resistance ammeter circuit connects them externally while the edges of the plates are ground, polished, and exposed to the environment. The environmental condensation on these plates forms a thin film of electrolyte which completes the galvanic circuit. The galvanic output of this cell becomes a measure of the corrosivity of the condensed film (or environment). The outdoor (e.g., aircraft carrier) and indoor (in simulated environmental chamber) testing of this probe has been successful in measuring the severity of the naval environment. This technique was used to evaluate potential corrosion inhibitors. However, in these evaluations the probe was half submerged into the test solutions containing the inhibitor and the salt etc. A plot of corrosion monitor probe output vs. time under some test conditions is shown in figure 2. The results illustrate a direct correlation between the monitor output and the corrosion and for inhibitive properties of the test media. Using this technique a large number of compounds are evaluated as potential anodic (or passivating type) inhibitors. Chemicals like dichromates, nitrites, osmiates, permanganates, etc. fall in this category.

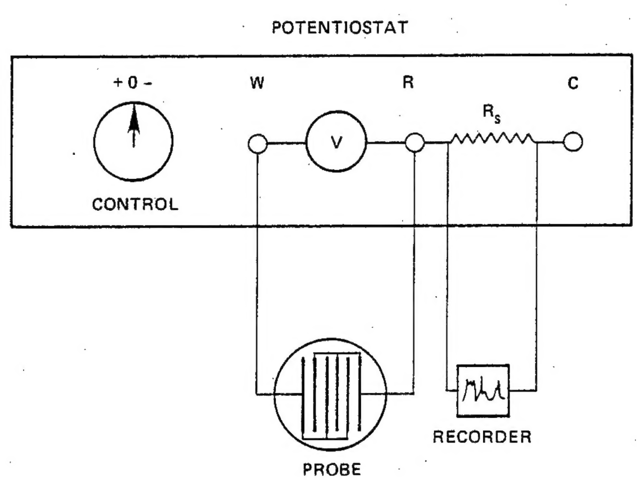


FIGURE 1 – INSTRUMENTATION FOR CORROSION MONITOR PROBE

2. *Ohr, J. and Clark, K. G.; "The Chemistry and Application for the Solubilization of Chromate Salts in Non-Poplar Organic Solvents"; NAVAIRDEVCEN Report No. NADC-78017-60.*

3. *DeLuccia, J. J. and Agarwala, V. S.; "Research on Catastrophic Damage Phenomena and Damage Control in Naval Aircraft Alloys"; IR Work Unit No. GC153, 1978 IR/IED Annual Report.*

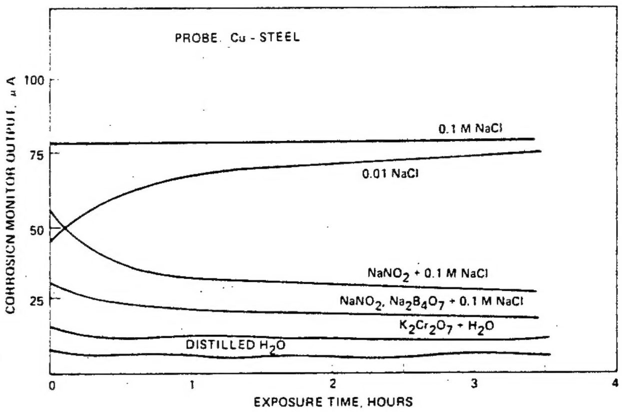


FIGURE 2 – USE OF CORROSION MONITOR PROBE IN INHIBITOR SELECTION

In order to evaluate cathodic type inhibitors; i.e., those which control the hydrogen evolution reaction, and electrochemical hydrogen permeation technique[4] was used. However, in these investigations the electrolyte in the input chamber (i.e., where cathodic charging occurs) was added with the test inhibitors to determine their effects on hydrogen entry into the metal (Armco iron). The results of such a measurement are illustrated in figure 3. Here, both palladium (Pd) and lanthanum (La) have shown a significant lower steady state for H permeation rate than the control without an inhibitor. In other words, both Pd and La have shown an effective cathodic inhibition as they impeded atomic H entry into the metal.

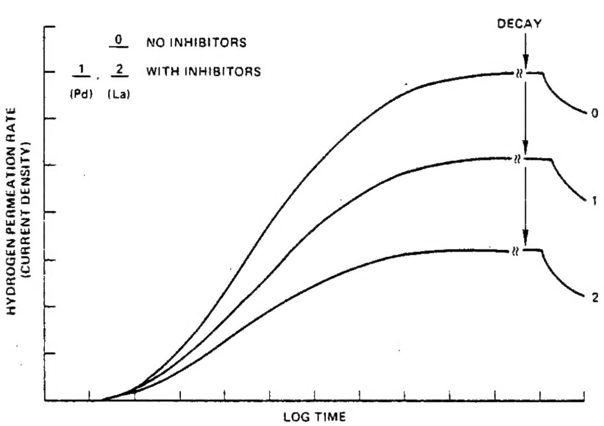


FIGURE 3 – EFFECT OF INHIBITORS ON HYDROGEN PERMEATION IN IRON

Based on the above knowledge and the experience gained from the earlier work[3] a few formulations have been made and evaluated. Adogen 464, known chemically as methyl trialkyl ($C_8 - C_{10}$) ammonium chloride, was used as a phase transfer catalyst to dissolve the inorganic compounds in mineral spirits. The tests were performed to investigate the effects of some of the combination inhibitors on low-cycle fatigue life of AISI 4340 steel (260-280 ksi) when exposed to high humidity and chloride containing environments. The details of these tests are described elsewhere[5]. A summary of the data obtained are given in table I. As shown in table I, the results clearly demonstrate that the concept of combining several functional inhibitors into one system was very effective in retarding crack growth rate. In particular, a combination inhibitor system containing dichromate, nitrite and borate compounds (c.f. table I) showed an excellent fatigue life for 4340 steel compared to the results shown by their individual components. However, when chloride was also added to the environment, the effect of inhibition disappeared until molybdate was added. This is because molybdate has been known to counteract the effect of chloride by influencing the kinetics of repassivation.

Some experiments were also performed to evaluate the effect of these inhibitors on stress corrosion cracking properties of 7075-T6 aluminum alloy. Double cantilever beam (DCB) specimens and the method described by Hyatt[6]

4. *Agarwala, V. S. and DeLuccia, J. J.; "Effects of a Magnetic Field on Hydrogen Evolution Reaction and its Diffusion in Armco Iron"; Proceedings of 7th International Congress on Metallic Corrosion, 1978, Rio de Janiero, Brazil.*

5. *Agarwala, V. S. and DeLuccia, J. J.; "New Inhibitors of Crack Arrestment in Corrosion Fatigue of High-Strength Steels"; to be published in Corrosion 1980.*

6. *Hyatt, M. V.; "Use of Pre-Cracked Specimens in Selecting Heat Treatments for Stress Corrosion Resistance in High-Strength Al Alloys"; Corrosion, Vol. 26 No. 11, 487-503 (1970).*

for determining the resistance to stress corrosion cracking in aluminum alloys were used for this evaluation. The results obtained, although only preliminary, indicate some slight inhibition effects on crack growth rate of 7075-T6 when exposed to high-humidity environment when dichromate, nitrite, borate, and molybdate inhibitor system was used. However, when chloride was also introduced into the notch area of the DCB specimen, the inhibitors did not show any crack retardation effect until after 2000 hours of exposure. A crack length/exposure time plot of these tests showed an ascending step type behavior which was much more pronounced when chloride was present in the system. The most aparent explanation of such a discontinuous cracking behavior probably lies in the effects of hydrogen as embrittlement failures do occur in intermittent cracking. Efforts are continuing to further confirm these results.

FUTURE PLANNING

Electrochemical investigation of selected candidate corrosion inhibitors will be continued to study their anodic and cathodic (hydrogen permeation) effects. Several other formulations will be made in other possible alternate non aqueous media to seek greater stability of the compounds present in them. Evaluation of the inhibitors will be continued and extended to other forms of corrosion such as exfoliation and wear.

The research as planned is expected to translate into useful products, procedures and techniques for fleet application. Progress has already been made in the development of the corrosion monitor probe and a formulation for inhibiting corrosion fatique in high-strength steel.

	INHIBITORS APPLIED TO NOTCH AREA	MECHANISMS INVOLVED	CRACK GROWTH RATE MICRO-IN./CYCLE	STRESS INTENSITY FACTOR ΔK, KSI $\sqrt{IN.}$	FATIGUE LIFE, CYCLES
	DRY AIR ONLY	NO CORROSION	12	70	17,000
MOIST AIR ONLY	NO INHIBITOR USED	SEVERE CORROSION AND H. E.	110	33	1,800
	DICHROMATE	PASSIVE FILM FORMATION	42	52	6,800
	NITRITE + BORATE	MOSTLY pH ADJUSTMENT	65	35	3,300
	HEXAPALLADATE	ACCELERATE H RECOMBINATION	45	>40	4,000
	LANTHANUM NITRATE	H GETTERING ACTION	50	>40	4,600
	DICHROMATE + NITRITE + BORATE	PASSIVATION AND pH ADJUSTMENT	27	55	9,000
	CERATE + NITRITE + BORATE	PASSIVATION AND pH ADJUSTMENT	38	45	6,400
MOIST AIR CHLORIDE	NO INHIBITOR USED	SEVERE CORROSION AND SEVERE H.E.	150	32	1,200
	DICHROMATE + NITRITE + BORATE	NO PASSIVATION, SEVERE H.E.	200	34	1,200
	MOLYBDATE	SOME PASSIVATION AGAINST CHLORIDE	61	46	4,500
	DICHROMATE + NITRITE + BORATE + MOLYBDATE	PASSIVATION, pH ADJUSTMENT AND CHLORIDE RESISTANCE	28	48	6,500

TABLE I – EFFECT OF FUNCTIONAL PROPERTIES OF VARIOUS CRACK ARRESTMENT INHIBITORS ON LOW-CYCLE FATIGUE OF HIGH-STRENGTH STEEL

METAL VAPOR LASER INVESTIGATION

Task No. ZR01107
IR Work Unit No. GC146

By L. C. Bobb, G. D. Ferguson, and M. B. Rankin

New potential lasing materials (chromium, indium, germanium iodide compounds) are described which emit radiation in the blue-green spectrum. Improved quartz and ceramic laser devices are presented for use with metal halide and pure metal vapors.

BACKGROUND

Pulsed metal vapor lasers (MVL) promise to provide efficient and reliable performance needed for various naval airborne applications[1,2,3]. Metal vapor lasers with emission in the blue-green spectrum (i.e., lead @ 405.7 nm, iron @ 452.9 nm and copper @ 510.6 nm) are useful in air-to-underwater optical radar applications. Short duration laser pulses, generated by metal vapor discharges, are used in optical radar systems to detect submarines or to map the coastal waters. MVLs are operated at high pulse repetition rates (PRR), which can be utilized for searching large ocean areas or communicating at high-data rates. Metal vapor lasers, which emit radiation in the near IR spectrum (i.e., lead @ 722.9 nm and calcium II @ 854.2 nm), are ideal for use in coastal surface surveillance and air-to-air target identification applications. Table I lists various metal vapors which lase or promise to lase at different wavelengths across the visible and near IR spectrums. The most developed MVL is copper (λ = 510.6 nm) with an output of over 40 watts[4] and an overall efficiency of 1%. Operating lifetimes of approximately 700 hours have been achieved in laboratory devices. However, reliable MVL devices remain to be developed for airborne use. In addition, efficient laser action needs to be demonstrated with metals having a more desirable wavelength than copper.

1. *Ferguson, G. D.; "Blue-Green Lasers for Underwater Applications"; 19th SPIE International Technical Symposium, Aug 1975*
2. *White, M. B.; "Blue-Green Laser for Ocean Optics"; Jour. Optical Engr, Mar-Apr 1977, Vol 16, No. 2, pp. 145-151*
3. *Ferguson, G. D.; "Blue-Green Laser Technology"; Proceedings of Laser Hydrography Symposium at NOAA, Rockville, Maryland, Oct 1977*
4. *Piper, J. A.; "Recent Advances in Metal Vapor Lasers"; Proceedings of Lasers 1979 Conference, Orlando, Florida, Dec 1979*

TABLE I – VISIBLE AND NEAR IR CYCLIC METAL VAPOR LASERS

Wavelength (A°)	Metal	Wavelength (Å)	Metal
3639	Pb	3269	Ge
4057	Pb	4086	Co
4062	Pb	4685	Ge
4529	Fe	4942	Cr
4722	Bi	4964	Cr
5106	Cu	5012	Fe
5341	Mn	5631	Sn
5420	Mn	5834	Re
5470	Mn	6142	Ba II
5782	Cu	6191	Ni
7229	Pb	6278	Au
8542	Ca II	6497	Ba II
8662	Ca II	7111	Ni
		7355	Co
		8689	

OBJECTIVES

The technical objective of this research is to investigate and develop pulsed metal vapor lasers with outputs in the 400 to 900 nm spectrum for use in naval optical radar and surveillance applications. The program goals include the following: (1) selection and evaluation of new metal vapor materials, (2) development of sealed quartz and ceramic devices, and (3) dem-

onstration of 10's watts output power at 400-3000 Hz PRR.

The anticipated payoffs from this research include the development of an improved laser transmitter for future naval airborne use, the development of improved laser materials and devices, the establishment of achievable laser specifications for contractor hardware development, and the development of expertise to be used to support and advise naval 6.2/6.3 systems' programs.

PROGRESS

Selection Of New Materials

In the search for new metal vapor laser materials which have emissions in the blue-green region of the spectrum, a thorough study of the existing literature was performed. The study included government reports, patents, the open literature including the Russian literature, and test books on laser and fluorescent lines. The results of the search have been compiled. From the compiled data, it would appear that the three most promising metals for use in the blue-green are germanium, chromium, and indium. In table II are shown some of the relevant physical parameters for these three metals. In table II, g is a statistical weighting factor, and A is the Einstein coefficient. The wavelengths are all in the region of interest; but, the temperatures to achieve sufficient partial pressures for the elements are too high. To solve this problem, the metal halides are used. For the iodides of chromium, germanium, and indium, the temperatures needed to obtain a partial pressure of 10^{-3} ATM are respectively, 500°C, 200°C, and 240°C. These temperatures are much more tractable.

In order to assess the practicability of fabricating a laser device wherein the active medium would be one of the above metal halides, it was decided to incorporate these materials into lamps for testing. A block diagram of the spectroscopy apparatus is shown in figure 1. The spectrometer is a Jarrell-Ash

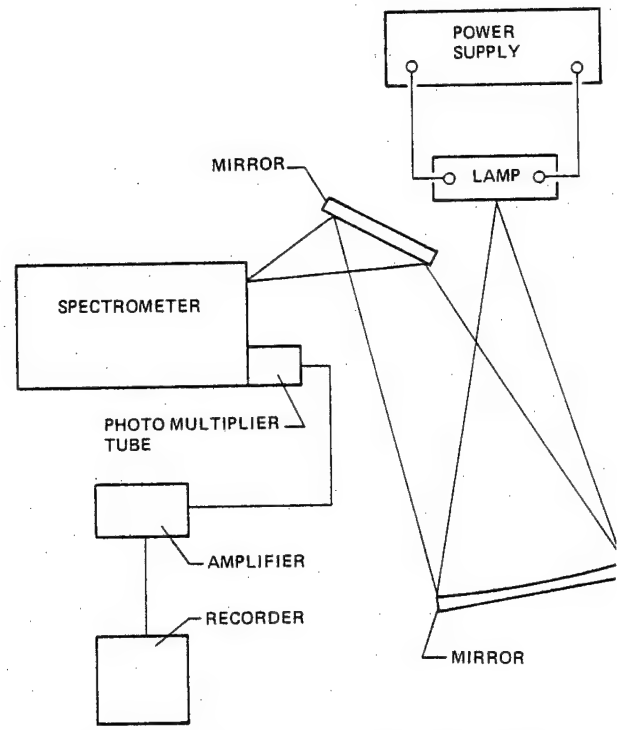


FIGURE 1 – SPECTROSCOPY APPARATUS

0.5 meter ebert, with a 30,000 groove/inch grating blazed at 5000 Å: The photomultiplier tube is an RCA 6199 (S-11) which has peak responsibility from 0.4μ to 0.5μ. The lamp is a quartz envelope 3/8" diameter x 6" long, with tungsten electrodes. One of the electrodes is made from a low work function tungsten alloy to enhance electron emission. The power supply

TABLE II – PHYSICAL PROPERTIES OF Cr, Ge, and In

METAL	WAVELENGTH (Å)	10^8/SEC) gA	BOILING PT (°C)	(°C) TEMP FOR PARTIAL PRESSURES OF 10^{-3} ATM
Cr	4942, 4964	.028, .014	2670	1480
Ge	4686	0.15	2830	1610
In	4511	2.2	2080	1240

is a high voltage 5(KV) double pulse circuit in which the spacing between pulse pairs can be varied and the repetition rate can be varied as well. The circuit and some of the components were fabricated in-house.

Spectra were obtained of the argon buffer gas and the GeI_4+Ar combinations. The spectra are fairly complicated inasmuch as various ionization states are present and Ge, I, and Ar have a great number of lines. After measuring the emission spectra of the lamps, it was decided that the spectra of Ge and Cr are too complicated and there are too many competing lines (as shown in figures 2 and 3) to accurately assess the laser possibilities in lamp form. Therefore, it was decided that several quartz laser tubes would be fabricated.

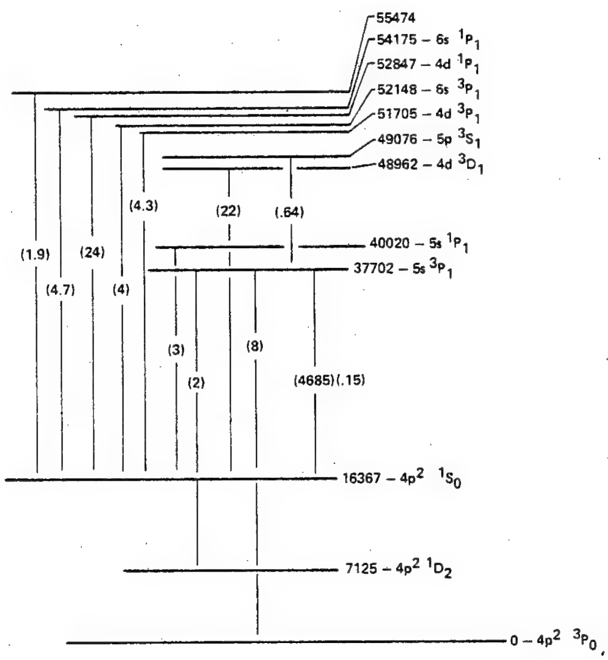


FIGURE 2 – Ge I

Quartz Laser Devices

Several types of quartz laser tubes were designed and constructed for use with metal halide vapors and the lowest temperature pure metal vapor (lead). Figure 4 shows the construction of a low-power quartz tube with Brewster angle windows. This design was used to further evaluate the new lasing materials, GeI_4 and CrI_2. The quartz tubes, after being

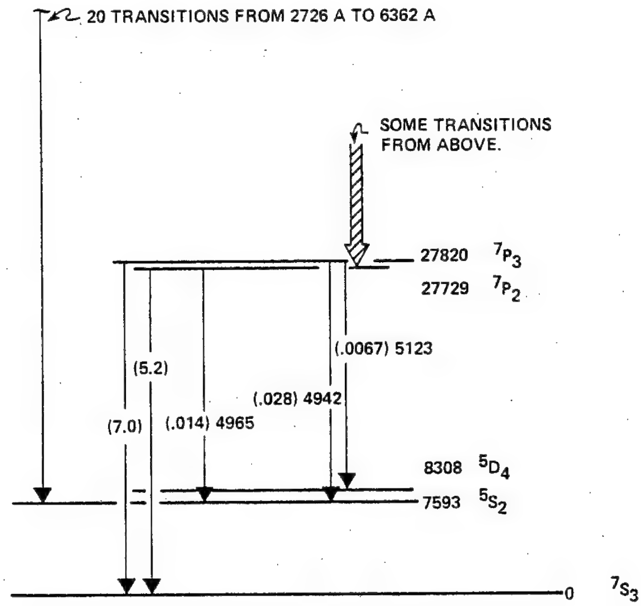


FIGURE 3 – Cr I

checked for pin holes, were filled with 5 grams of anhydrous CrI_2. The tubes were then baked at over 100°C and pumped down to 5 x 10^{-6} torr. The tubes were then filled with 5 torr of neon gas and sealed. Heating elements were then wrapped around the tubes and the tube was insulated. After developing cracks in several tubes, it was realized that the ultrabond cement used to hold the heating wire in place was locally stressing the quartz and causing tube fractures. The most recent tube has been fabricated to avoid these problems; and, emission measurements on this tube will begin shortly.

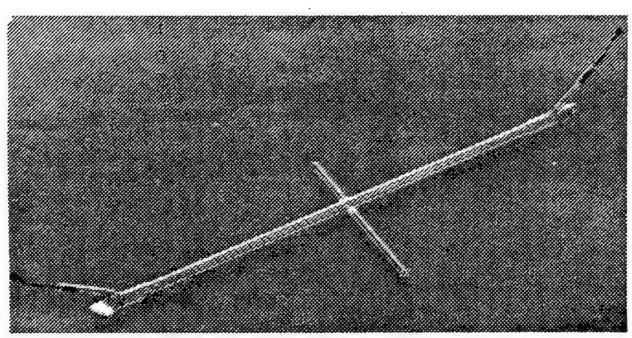


FIGURE 4 – LOW POWER QUARTZ LASER TUBE

A new design of quartz laser tube has been fabricated by Precision Glass according to NAVAIRDEVCEN specifications. The advantages of this new design are twofold: (1) The tube can be heated inside of a split tube furnace, therefore, each tube does not have to be wound with heater wire, and (2) the tube can be disassembled and cleaned after use. It is hoped that this new design will facilitate laser tube construction.

A quartz tube designed for self-heated operation at high-input power levels is shown in figure 5. The design includes the following features: (1) all hot reentry windows free of vapor deposition, (2) Bomco quartz moly sleeve seals for coaxial discharge operation, and (3) Calora-coated molybenum to prevent oxidation at 500°C. The tube will be tested and evaluated for use with various metal halide compounds operating at moderate (500°C) temperatures. A similar configuration has been recently designed for use with pure lead vapors. However, a new type of point electrodes with double moly cup seals are employed for use at the elevated 1000°C temperature level.

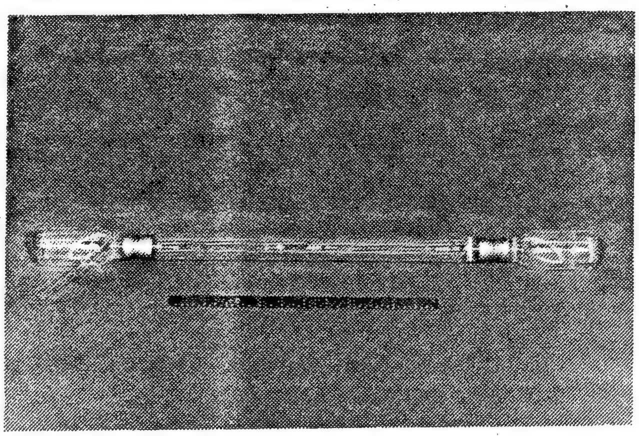


FIGURE 5 – COAXIAL DISCHARGE QUARTZ LASER TUBE

A ceramic laser device for use with pure metal vapors at temperatures in the 1100°C to 1500°C range was developed for test and evaluation (figure 6). The critical part of the tube is the ceramic-to-metal seal, which is a zirconium-nickel active alloy seal. The seal is designed to operate in the 600°C to 800°C range. A complete laser system with machinable ceramic insulation and a flowing gas system was developed. Steady and uniform electrical discharges were obtained

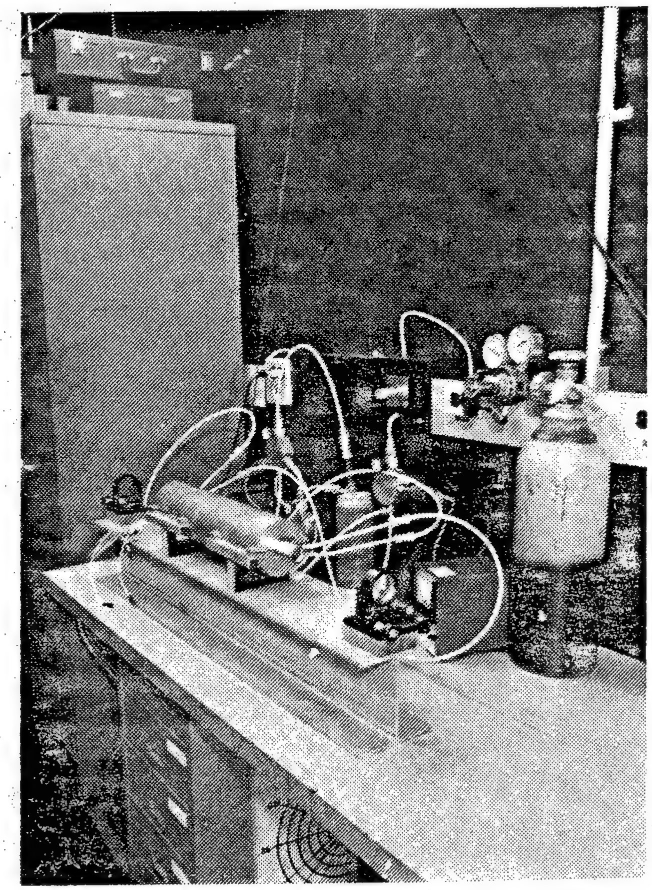


FIGURE 6 – CERAMIC METAL VAPOR LASER SYSTEM

with neon gas at pressures ranging from 1 to 100 torr. With 15,000 volts on the capacitor, 600 amp discharges were generated with a 100 nanosecond rise time. The system was operated at a PRR of 3 KHz with 600 watts of input power. A problem of excessive heating around the exit window near the cathode occurred. Tube failure occurred because of positive ion sputtering around the edge of the window. A new tube was designed with an insulated insert to cure this problem. Tests will be conducted in the near future to evaluate the new design.

Chromium, indium and germanium iodide compounds were selected as new potential lasing materials for use in the blue-green spectrum. The compounds will generate sufficient vapor pressure at low to moderate temperatures (240 to 500°C). Quartz laser tubes were developed for lasing metal halide compounds in oven and self-heated configurations. A ceramic laser tube was developed for the lasing of pure metals at the 1100 to 1500°C temperatures.

FUTURE PLANNING

The technology developed under this IR program has transitioned into the following 6.2 and 6.3 systems projects: (1) Coast Guard AIREYE Project, (2) Defense Mapping Agency Hydrographic Airborne Sounder System, (3) NAVELEX Blue-Green Laser Technology Program, and (4) NAVAIR Surface-to-Air Target Surveillance Program. For example, the in-house technology developed in the area of ceramic-to-metal and glass-to-metal seals has been useful in selecting and directing contracts to develop reliable airborne systems. New short-pulse width lasers are under development for future use in coastal water mapping. A lead vapor laser with improved life and reduced cost is under development for use in coastal surveillance applications.

It is planned to utilize the technology developed under this program by developing improved metal vapor laser devices for use on the various systems programs. In addition, new materials such as the rare earth vapors are currently being explored for potential use in future naval systems (i.e., satellite-to-underwater communication).

THIS PAGE LEFT BLANK INTENTIONALLY

DEVELOPMENT OF ADVANCED AIRBORNE EXECUTIVE PROGRAM

Task No. ZR01403
IR Work Unit No. GC180

By C. S. Czaplicki and F. C. Prindle

The development of a standard executive design to accommodate specific needs of a distributed computer configuration is being investigated.

BACKGROUND

Computer loading and reliability factors are driving new airborne systems toward distributed computer configurations. The avionic sensor technology has been developed to such a state-of-the art that only small gains in signal-to-noise ratio and sensor sensitivity can reasonably be expected. The avionic platforms must now look towards such developments as advanced signal processing techniques, new detection and classification algorithms and multi-sensor correlation to improve system performance. Implementation of these developments require significantly more processing power than currently exists in the fleet. The time is ending for avionic platforms which have only a single control processing unit receiving inputs from various sensors and sensor operators.

Current planning for such platforms as P-3, Light Airborne Multi-Purpose System (LAMPS), S-3A, Advanced Integrated Display System (AIDS), V/STOL and Basic Avionic Subsystems Integration Concepts (BASIC) includes some type of parallel processing. There are several advantages associated with a multi- processing computer configuration as compared to a single processor system. One is an increase in reliability and processor availability. The system can be designed to gracefully degrade if a processor fails. Processing functions can be redistributed to provide a reduced capability in the event of a processor failure. Another advantage is that with proper design, the processing capabilities of the avionic system can be expanded by incorporating additional processors when the processing requirements increase.

Current efforts by the Navy to reduce the unnecessary proliferation of hardware and software is evident in the specification of standard computers and languages such as the AN/AYK-14(V) procurement and the SPL/I language development. The demand for a standard computer architecture and a standard higher-order language by upper Navy management is becoming more imperative. The demand for more programmable devices will increase as surveillance and weapon systems become more complex. Transportability and commonality can only be realized if standard hardware and software can be applied across platforms.

The design of a standard executive program which can be applied to various platforms using similar distributed processing architectures offers significant benefits. These include the reduction of development costs, reduction of errors due to legacy and the inherent transportability across user platforms.

OBJECTIVES

The main objectives of this program is to postulate, implement and test a distributed executive design which will meet the requirements of various distributed processing configurations. Future project requirements will be reviewed and a distributed processing architecture will be chosen which best meets the near-term future Navy avionic requirements. The goal is a general purpose executive program which would provide increased reliability, graceful degradation and expanded processing capability while providing flexibility in architectural design of the configuration of computers within a system.

PROGRESS

Recent trends in system architectural designs for future Navy avionic systems point towards the use of standard AN/AYK-14 computers and micro-processors interconnected via the tri-service 1553A data bus. For the purposes of implementation and experimentation the architecture depicted in figure 1 has been used to demonstrate the execution of the Advanced Distributed Executive for the AN/AYK-14 (ADEX-14).

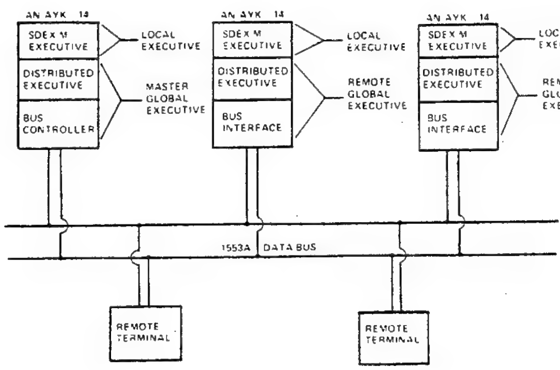


FIGURE 1 – ADEX-14 SYSTEM ARCHITECTURE

The executive is divided into two distinct parts residing in all processors: a Local Executive and a Global Executive. The Local Executive is the the AN/AYK-14 SDEX/M Executive. The Local Executive interfaces the Global Executive with the hardware operations and provides local executive services for both the Global Executive and applications running in a single AN/AYK-14 computer.

The Global Executive is composed of the Distributed Executive and the Bus Controller. There are two versions of the Bus Controller. One version resides in the Master Processor and controls all system wide functions, which include Data Bus management, system wide initialization, system time management, system error recovery, and data and resource allocations. A copy of the other version of the Bus Controller resides in each Remote Processor and performs only remote interfacing with the bus, such as the transmissions of synchronous bus messages.

The Bus Controller has been coded using CMS-2M, a high-order language for the AN/AYK-14 computer. It has been tested in the BASIC Laboratory using a dual-bus configuration of one Master Processor, one Remote Processor, and a Remote Terminal. Performance monitoring software has been added to measure the bus loading and Central Processor Unit loading. Error processing improvements have been added to cope with bus or remote terminal failures.

Global Services Specification for the application and how they relate to the overall process control has been formulated and as a result the "ADEX-14 Executive Performance Specification" dated 1 October 1979 has been published. The Distributed Executive has been designed and the distributed processing interfaces have been defined with SDEX/M. The coding for the Distributed Executive is 50% complete.

FUTURE PLANNING

The coding of the Advanced Distributed Executive for the AN/AYK-14 (ADEX-14) will be completed. The integration of the Distributed Executive, SDEX/M and the Bus Controller will be accomplished and the resultant ADEX-14 will be tested in the BASIC Laboratory using all of the available AN/AYK-14 computers and remote terminal equipment.

REPEATED ACCELERATION EXPOSURE EFFECTS

Task No. ZR04106
IR Work Unit No. GC182

By E. Hendler, M. M. Cohen, and D. C. Johnson

A detailed study has been made of the physiological and performance responses of human subjects during and following repeated exposures to increased levels of acceleration loads.

BACKGROUND

At the present time, there is no validated reproducible method to determine the magnitude and nature of cumulative deleterious effects on pilots of repeated exposure to G loads. Because of this, there is no way of knowing how often a pilot may be exposed to G loads without affecting his performance and well-being. Knowledge of the specific conditions under which G loads are applied, such as seatback angle, anti-G suit inflation pressure and distribution, degree of muscular tensing (M-1 maneuver), level and duration of G load, etc., is still insufficient to indicate how long rest (recovery) periods should be between successive G-load exposures. Such information is required to prevent overexposure of military flyers to conditions producing physical damage, fatigue, and disruption of flight performance. This problem becomes extremely important because present and future high-performance Navy fighter aircraft, such as the F-14 and F-18, are capable of sustaining very high accelerations during air combat maneuvers. These accelerations approach or exceed levels, durations, and repetition rates which are tolerable to the human operator.

OBJECTIVES

The technical objective of this work is to quantify the physiological and performance responses of human subjects to repeated accelerations to determine the cumulative effects of such exposures as well as the recovery times required to reverse any decrement that occurs. It is planned to achieve this objective by exposing volunteer subjects to repeated accelerations of varying levels and durations while evaluating the effects of operational protective techniques, such as the use of the anti-G suit, performance of the M-1 straining maneuver, and change in the aircraft seatback angle.

PROGRESS

The experimental portions of four phases of this study have been completed; data analysis of the first phase has been completed and a report has been published[1]. For all phases, male volunteer subjects were exposed to acceleration-time pulses while seated in the gondola of the NAVAIRDEVCEN Dynamic Flight Simulator (DFS). The DFS is a computer-controlled, man-rated centrifuge characterized by its relatively long arm (15.2 m) and its capability of producing very high rates of onset of acceleration (up to 10 G's). The position of the gondola, which contains the payload, is controlled by the movements of two gimbals.

Table I summarizes the identifying characteristics of each of the four phases. For all phases, the subjects wore Electrocardiogram (ECG) electrodes on their chests and a single or double (bilateral) doppler flowmeter transceiver attached to the side of their forehead, overlying the temporal artery. For Phase I, respiratory rate was measured with a thermistor attached to a boom microphone positioned close to the nostrils and lips. In all cases, the subjects wore underwear, shoes, socks, and a lightweight coverall. For Phases III and IV, the subjects also wore standard USN anti-G suits which were inflated under appropriate G_z conditions in accordance with the specifications for anti-G valves installed in aircraft. The phases shown were conducted over an extended period, which

1. *Hendler, E. and Johanson, D. C.; "Some human responses to + G_Z pulses"; AGARD Conference Proceedings No. 253, pp. A27-1 to A24-17, June, 1979.*

TABLE I – INDENTIFYING CHARACTERISTICS OF THE FOUR PHASES

PHASE	G_Z PLATEAU LEVEL	G_Z PLATEAU DURATION	PULSE S = SINGLE D = DOUBLE	INTERPLUSE INTERVAL (s)	SUBJECTS	MUSCULAR TONE	ANTI-G SUIT
I	1.5, 2.0, 2.5, 3.0, 3.5	"0", 10, 20 40, 80	S	–––––	TF RP SS JT JR	Relaxed	–––
II	2.0 & 3.0	20 & 40	D	4, 8, 16, 32, 64	RP MR JR TF SS	Relaxed	–––
III	3.0 & 4.0	20 & 40	D	4, 8, 16, 32, 64	CH JM SS RP MR	Relaxed	+
IV	4.0 & 5.0	20 & 40	D	4, 8, 16, 32, 64	DB RP RR CR	Straining (M-1)	+

accounts for the fact that the subjects in each phase are not identical. In fact, only one subject (RP) participated in all four phases. While the G_Z plateau levels increased from one phase to the next, anti-G protection, in the form of the anti-G suit and the M-1 maneuver, was also added.

The subjects were seated upright in the DFS gondola, restrained with a standard Navy torso harness, and viewed a 13 cm black and white TV screen positioned about 86 cm directly in front of, and level with, the seat headrest (see figure 1). A two-axis, force displacement side-arm controller, mounted horizontally on the right arm rest, was used by the subject to perform a tracking task. Activation of a spring-loaded button on the left hand grip extinguished a red light located at eye level, 38 cm to the subject's left of the center of the TV screen. The tracking task consist of keeping two perpendicular lines (needles) of an Attitude-Direction Indicator (ADI) crossed in the center of the display. The needles were driven by the mixed input of several oscillators, so that their movements appeared quite erratic to the subjects. When either or both needles moved more than one-fourth of their full-scale displacement from

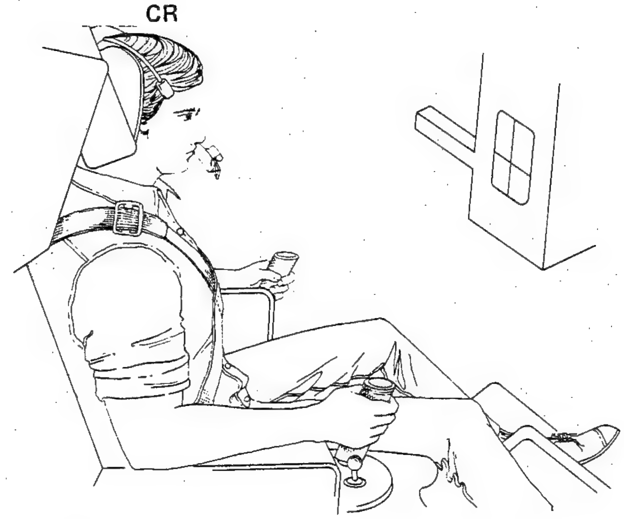


FIGURE 1 – SEATING OF SUBJECTS IN THE NAVAIRDEVCEN DYNAMIC FLIGHT SIMULATOR

the center of the screen, an electronic buzzer was sounded. The rate of needle movements and their direction of movement were controlled by manipulation of the side arm controller. On-off responses to the light were recorded (response time), the subjects having been instructed to turn off the red light, using their left hand switch, as soon as possible after

they noticed that the light had been turned on. The percent of time the tracking task needles remained outside the central screen area was recorded as tracking error. Continuous recordings of ECG, heart rate, and doppler pulsatile and mean blood flow velocity were also made. Each subject received a complete physical examination prior to and following each day's G exposures, and blood and urine samples were examined and analyzed at regular intervals.

EXPERIMENTAL DESIGN

The experimental design is evident from examination of tables I and II. In Phase I, 25 different single acceleration pulses resulted by combining the 5 G_z plateau levels with each of the 5 G_z plateau durations ("O" indicates a momentary peak at the desired G_z level). Each of the 5 subjects was exposed daily to 5 different pulses, so that all 25 pulses were experienced by all 5 subjects each day, and by any given subject, every 5 days. The sequence of pulse exposures for each subject in Phase I was reversed every 5 days, so that each subject experienced the same daily sequence of pulses during his first and third 5-day periods, and the reverse sequence on the second and fourth 5-day periods. In Phases II to IV, double acceleration pulses were applied, the second pulse being identical to the first. Table II shows the combinations of pulse plateau level, plateau duration (20 or 40 s), and interpulse interval (4 to 64 s) applied over a 5-day period to each subject. H and L refer to the higher and lower plateau levels, respectively, for each of the Phase II to Phase IV runs. The sequence of runs shown in table II was repeated once in a subsequent 5-day period. For all runs in all phases, the acceleration pulses were haversine in shape and included a 4 s onset and 4 s offset. Each exposure or run in Phase I consisted of a 1 min pre-period, and acceleration period in which the acceleration pulse was applied, and three successive 1 min recovery periods (post 1, post 2, and post 3). For Phases II to IV, each run consisted of a 1 min pre-period, an acceleration period (accel 1), an interval period, an acceleration period (accel 2), and two successive 1 min recovery periods (post 1 and post 2). One-

TABLE II – COMBINATIONS OF PULSE PLATEAU LEVEL, PLATEAU DURATION AND INTERPULSE INTERVAL APPLIED OVER A 5-DAY PERIOD TO EACH SUBJECT

	S1	S2	S3	S4	S5
DAY 1	L 40 64 H 40 8 L 20 8 L 40 32	H 40 32 L 40 4 L 20 16 L 20 64	H 40 4 H 20 16 H 20 64 L 20 32	L 20 32 H 20 8 L 40 32 L 20 64	L 20 64 L 40 16 H 20 4 L 20 32
DAY 2	H 40 4 L 20 32 H 20 8 H 20 16	H 20 16 L 20 8 L 40 32 H 40 8	H 20 4 L 20 16 L 20 4 L 40 16	H 40 8 H 40 4 H 20 16 L 40 64	H 40 4 H 40 8 H 20 8 L 20 16
DAY 3	L 20 64 H 40 32 H 20 32 L 40 16	H 20 8 H 40 4 H 20 64 L 40 8	L 20 64 H 20 8 H 40 8 H 40 64	H 40 32 L 20 8 H 40 64 H 20 4	H 40 64 L 40 32 H 40 16 L 40 64
DAY 4	L 40 8 H 40 16 H 40 64 H 20 4	H 20 32 H 40 64 L 20 4 L 40 64	L 40 4 L 40 64 H 40 16 H 40 32	H 40 16 L 20 4 H 20 64 L 40 4	H 20 16 L 40 4 L 40 8 H 20 64
DAY 5	H 20 64 L 20 4 L 40 4 L 20 16	H 40 16 L 40 16 H 20 4 L 20 32	L 20 8 L 40 32 L 40 8 H 20 32	L 40 8 H 20 32 L 40 16 L 20 16	H 40 32 L 20 4 H 20 32 L 20 8

minute rest periods intervened between successive runs, during which the subjects stopped performing the response time and tracking tasks and relaxed as completely as possible. Between pulses, the DFS gondola was rotated slowly (applying a load of 1.03 G_z to the subject) to eliminate any slight motion arti-facts incidental to its being completely stopped and started. Deviations from the planned schedules occurred occasionally, and during Phase IV, one of the trained subjects withdrew and could not be replaced in the time available.

RESULTS

Comparison of performance results of subjects during Phase I showed that those subjects having higher tracking error scores had lower response time scores, and vice-versa. This effect was particularly evident when the prephase mean response time (MRT) and mean tracking error (MTE) for each run and test day were examined, and shows a type of tradeoff behavior which has also been described by others. All of the dependent variables measured in Phase I were plotted as functions of both plateau G levels and duration of plateau G for each period of the run. Mean heart rate (MHR) increased linearly with G level and logarithmically with duration; MTE increased exponentially with G level but decreased logarithmically with plateau duration. Mean respiration rate (MRR) remained higher during acceleration than in the pre and recovery periods, increasing significantly during acceleration when the level of 2.5 G was exceeded. However, as with MTE, MRR showed a marked logarithmic decrease with increasing duration of plateau G. Best fit equations were derived describing these relationships. MRT, like MRR, showed a marked increase above levels of 2.5 G; its relation with plateau duration was irregular, showing a peak at 10 s and a low point at 40 s. MRT scores at "0", 10, and 20 s were appreciably greater during acceleration periods than those at 40 and 80 s. In summary then, while increasing G levels caused increases in values of all the dependent variables, increasing duration of acceleration plateau levels resulted in decreases in dependent variable values, except for MHR. This may indicate an adaptive reaction on the part of the subject for those responses over which he exercises complete or partial voluntary control.

Recovery of the subjects following cessation of acceleration appeared to be rapid, even for the highest plateau levels and durations. Multiple regression equations were derived describing the relations between MHR, MTE, and MRR with G plateau level and G plateau duration:

$$\mathrm{MHR} = 59.99 + 9.03\,G_z + 3.44 \ln t, \qquad R^2 = 0.87$$
$$\mathrm{MTE} = 36.18 + 0.63 \exp G_z - 3.31 \ln t, \qquad R^2 = 0.91$$
$$\mathrm{MRR} = 22.23 + 0.11 \exp G_z - 1.52 \ln t, \qquad R^2 = 0.73$$

R^2 is the multiple correlation coefficient. No attempt was made to fit MRT to G and t, because of its erratic behavior. For MHR, MTE, and MRR, the percentages of explained variation accounted for by variations in G were about 55, 57, and 32, respectively, while percentages of explained variation accounted for by variations in t were about 45, 43, and 68, respectively. Measures made on the blood and urine samples were essentially negative and the overall results were interpreted as indicating no residual stress in the subjects who participated in this phase of the study. Twenty-four hour urine samples collected at the end of the study were examined for indicators of anoxic and anxiety stress, and the results obtained were interpreted as indicating no residual stress in the subjects.

In Phase II of the study, before and after exposure to acceleration, each subject performed pulmonary function tests using a computerized wedge spirometer. Included in these measurements were forced vital capacity, forced expiratory volume, maximum mid-expiratory flow rate, forced inspiratory vital capacity, maximum mid-inspiratory flow rate, slow vital capacity, expiratory reserve volume, and inspiratory capacity. A preliminary evaluation of these data indicates that the largest differences between pre and post values occurred in maximums mid-inspiratory flow rate, but the differences examined were not statistically significant. It is planned to install within the DFS gondola, a pneumotachometer to make the same pulmonary function measures more immediately before and after acceleration exposures.

For Phase II conditions, it was found that the predominant effect on the magnitude of MTE was due to the plateau duration of the acceleration pulses, with the shorter duration pulses (20 s) producing greater errors than the

longer duration pulses (40 s). This effect outweighed the effect of plateau G level, so that MTE or the combination of 2 G for 20 s was greater than that for 3 G for 40 s. MTE decreased almost linearly across interpulse periods, with the error greater for the shorter and less for the longer periods. The effects just described hold for the second acceleration pulse, as well as for the first. MTE during the acceleration pulse periods was significantly greater than during the pre, interpulse, and post (recovery) periods, although after the longer interpulse periods (32 s and 64 s), MTE during the post periods 1 and 2 was relatively increased. MHR increased significantly during both acceleration pulse periods, and was relatively lower during the 20 s duration pulses as compared to those of 40 s duration.

In Phase III, MTE rose significantly in the acceleration pulse and interpulse periods, as compared to pre and post periods; was higher at the 3 G level than at the 4 G level, and was higher during the acceleration plateaus lasting 20 s as compared to those lasting 40 s. As in Phase II, the magnitude of MTE remained significantly higher than the mean for the shorter interpulse periods of 4 s and 8 s, while dropping progressively for longer interpulse periods. MHR in Phase III rose significantly during the acceleration periods, with the first acceleration pulse showing a slightly higher MHR than the second. MHR during the 3 G plateau pulses was significantly greater than that during the 4 G plateau pulses, with the MHR levels during the two acceleration pulses and the interpulse period greater than the pre and recovery periods. The opposite relation between MHR levels and the corresponding periods was found for the 4 G runs.

MTE in Phase IV was higher during the two acceleration periods than in the other periods of the runs, and showed an almost linear decrease in magnitude with increasing duration of the interpulse periods. MTE during runs with acceleration plateaus of 20 s duration was significantly greater than MTE during runs with acceleration plateaus of 40 s duration. The difference in MTE due to G level was just significant ($p = 0.05$), with the value at 5 G being greater than that at 4 G. MTE values in the acceleration and interpulse periods were significantly greater when the acceleration pulse duration was 20 s as compared to pulse durations of 40 s, with an identical but less marked effect for 4 and 5 G plateau levels, respectively.

MTE in Phase IV reached its peak during the 4 s interpulse period, and declined with longer interpulse periods for the runs containing 4 G plateau accelerations. In addition, for these runs, as MTE declined during the interpulse period, it increased with increasing interpulse period in the pre and post phases. During the 4 G acceleration pulse, MTE also decreased with longer interpulse periods. At 5 G, the decline of MTE with runs containing longer interpulse periods was less marked than that which occurred in the 4 G runs; also at 5 G, MTE levels during the acceleration periods were reduced relative to those in the pre and post periods. For both 20 s and 40 s plateau durations, with longer interpulse periods the relative magnitude of MTE decreased compared to its magnitude during corresponding pre and post periods.

MHR in Phase IV was very highly significantly different during the acceleration periods than in the pre and post periods, and was significantly greater at 5 G than at 4 G. MHR decreased with increasing interpulse durations when the various periods of the runs were compared, and the interaction between periods was very highly significant because of the higher levels of MHR seen during the 5 G acceleration periods and their interpulse periods as compared to the corresponding periods at the 4 G plateau level.

FUTURE PLANNING

Because of the variability in MRT, no significant changes in this variable could be identified in the analysis of Phases II to IV of this study. MRR was not measured in these phases because of inherent shortcomings in the methodology; as indicated above, plans are underway to obtain other measures of respiratory function. No significant changes in the analysis of blood and urine samples were found which could be attributed to the experimental conditions. Further analysis of the data collected is planned, and additional phases are scheduled in which subjects will be exposed to acceleration while in the supinated position.

THIS PAGE LEFT BLANK INTENTIONALLY

ASTRO-GEODETIC MEASUREMENT OF VERTICAL DEFLECTION WITH GPS AND ADVANCED INS

Task No. ZR01407
IR Work Unit No. GC194

By J. A. Calabria

The basic feasibility of the Astro-Geodetic measurement of vertical deflection has been established. A computer program has been developed for the simulation and analysis of the recovery of vertical deflections for Global Positioning System (GPS) and Electrically Suspended Gyro Monitor (ESGM) data. This program has been exercised to determine the effects of ship speed, fix accuracy, survey duration and model parameters on the resultant vertical deflection accuracy. These results have been useful in determining accuracy and sensitivities which may be used for projecting the configuration of future surveys.

BACKGROUND

Current trends in Inertial Navigation System (INS) technology indicate increasingly more accurate systems are being developed, largely through ultra precise gyro development such as Electrically Suspended Gyro (ESG) and through sophisticated filter processing of position fixes from navigation aids. This increasingly successful solution of the INS internal error source problem exposes more clearly the remaining problem to be an external one, namely: deflection of the local vertical (vertical deflection) due to gravity anomalies.

Attempts to combat this problem involve compensations derived from maps made from a prior survey of the vehicle's operating area. Currently, deflection of the vertical is derived from classical processing (Vening Meinesz techniques) which requires an immense amount of surveying by ships; consequently deflection of the vertical map production of operating areas is slow and very costly. The advent of highly stable INS such as ESGM and the continuously available Global Positioning System (GPS), a high-accuracy navigation satellite system, together with the development of more sophisticated algorithms and advanced data processors, has suggested study of the Astro-Geodetic technique. Combining Astronomical data from INS with Geodetic data from GPS may lead to a highly accurate, rapid measurement technique for vertical deflections. The perfection of this technique will enable surface ships to survey vertical deflections at one or two orders of magnitude faster rate than currently possible and may also provide a capability to directly determine compensations on board an operational vehicle for unmapped areas.

OBJECTIVES

The objective of this work unit is to develop vertical deflection measurement techniques by using new systems such as advanced INS and GPS. These new systems provide precise Astronomical (INS) and Geodetic (GPS) navigation information which will be used to obtain Astro-Geodetic measurements directly and continuously. This will significantly reduce the time currently required for gravity surveys and may also provide an on-board capability to enhance operational vehicle navigation accuracy in unmapped areas.

PROGRESS

It was postulated that optimal smoothing techniques would offer the most promise for Astro-Geodetic Vertical Deflection measurement. Application of the techniques of optimal smoothing requires the framing of the problem of vertical deflection estimation in canonical form. Toward this end a vector error propagation block diagram for the ESGM as disturbed by vertical deflections was derived. This result is presented in figure 1 where:

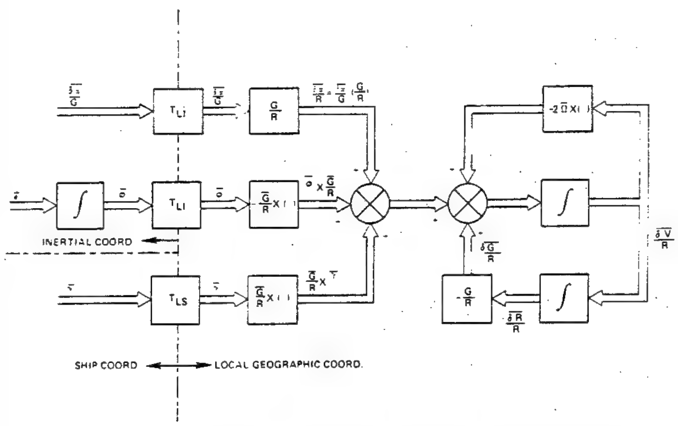


FIGURE 1 – VECTOR ERROR BLOCK DIAGRAM

$\overline{\delta R}$	=	vector position error*
$\overline{\delta V}$	=	vector velocity error*
$\overline{\phi}$	=	vector misalignment of instrumented inertial frame
$\overline{\delta\alpha}$	=	vector accelerometer error
$\overline{\gamma}$	=	vector small angle vertical deflection (i.e., actual $\overline{G'} = \overline{G} + \overline{\gamma} \times \overline{G}$
$\overline{G}$	=	gravity vector normal to ellipsoid of reference (including centrifugal effects)
$\overline{\Omega}$	=	vector earth rate
$\overline{R}$	=	radius of earth
T_{LI}	=	transformation from inertial to local geographic coordinates
T_{LS}	=	transformation ship to local geographic
$\overline{\delta G}$	=	error in the computed gravity vector

Note the use of the transformation from inertial to local geographic coordinates, T_{LI}. This accomodates a situation where it is desirable to model gyro and accelerometer errors in an inertial frame yet, modeling of vertical deflections and the Schuler loop call for the use of a local geographic frame.

Some insight is immediately available from study of figure 1. If $\frac{\overline{\delta R}}{R}$ (angular position error) is known perfectly, then it is seen that the sum of the horizontal components of $\frac{\overline{\delta\alpha}}{G}$, $\overline{\phi}$ and $\overline{\gamma}$ are likewise known perfectly. Thus the problem reduces to separating $\overline{\gamma}$ are likewise know perfectly. Thus the problem reduces to separating $\overline{\gamma}$ from $\overline{\phi}$ and $\frac{\overline{\delta\alpha}}{G}$.

The proposed strategy is to start and end** a survey leg at (the same or two different) points of known vertical deflection. Then since vertical deflection is known (assumedly, perfectly) the sum of horizontal components of $\overline{\delta\alpha}$ and ϕ is likewise known at both ends of a survey leg. Thus the interpolation of vertical deflection between the two points of known defection is dependent on how much the sum of $\overline{\delta\alpha}$ and $\overline{\phi}$ (horizontal components) wanders over the duration of the leg.

The Vector Error Propagation Block Diagram of figure 1 was, in a straightforward manner, expanded as given in reference[1]. The vertical deflection was modeled in accordance with the third order undulation model of reference[2]. This allows the enhancement of vertical deflection estimation through use of height information. The error in retention of the vertical frame, $\overline{\phi}$, is modeled in accordance with reset equations for the ESGM. A simple exponetially correlated model was used for accelerometer errors, $\overline{\delta\alpha}/G$. Reasoning, that the high accuracy of the GPS system would obviate the necessity for complexity, a simple exponentially correlated model was likewise used for GPS fix error.

*Horizontal components only, in local geographic frame.

**Future Work will relax the requirement to end at a surveyed point.

---

1. *S. L. Fagin Associates; "Development of Methods for Measurement of Vertical Deflection"; prepared for Naval Air Development Center, Contract N62269-78-M-8754, 19 Jan. 1979.*

2. *Jordan, S. K.; "Self-Consistent Statistical Models for the Gravity Anomoly, Vertical Deflections, and Undulation of the Geoid"; JOURNAL OF GEOPHYSICAL RESEARCH, 10 Jul 1972, 77, No. 20, 3660-3666.*

Having modeled the problem of recovering vertical deflections in the required canonical form a computer program was developed to simulate this application. This program was then exercised using its Monte Carlo and covariance generation features to determine the feasibility and potential accuracy of this method and its sensitivity to the chosen error models. This analysis would be useful in determining the requirements for future vertical deflection surveys.

A "baseline" set of parameters were selected as representative of the accuracies expected of GPS and the ESGM system. The simulated vertical deflections, the smoothed estimates thereof, the errors (difference of above two), and covariances were generated. The direction averaged covariance only is plotted*** in figure 2. As can be seen from this curve the 1 sigma covariances are near zero at the beginning and end of the 24-hour period. This reflects the assumption that vertical deflections are known at beginning and end of the survey. Further, a comparison of this result with the Monte Carlo results (not shown) indicate that in general the larger simulated errors occur where predicted and look reasonable.

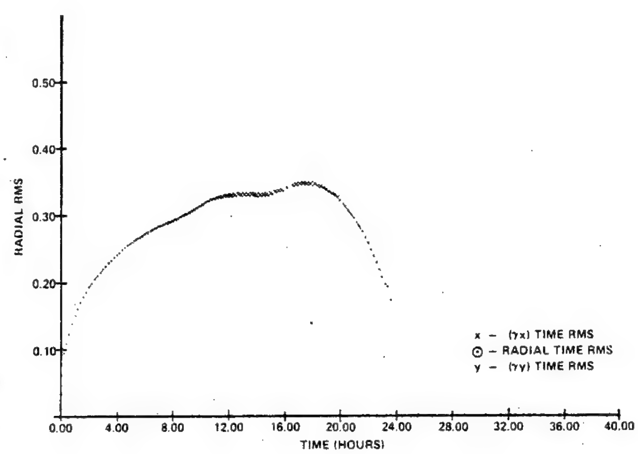


FIGURE 2 – BASELINE RESULTS

***All figures represent normalized results.

(U) A considerable number of runs were made to establish the effect of a number of parameter variations on predicted vertical deflection estimation accuracy.

Horizontal fix accuracy was varied from 0.1 to 100 meters with vertical (height) error assumed twice that level. The result of this parameter variation is shown in figure 3.

The effect of varying accelerometer errors on vertical deflection estimation were performed by quadrupling/halving initial covariances, P(0), and q. The insensitivity of the results to these variations indicates that, for the model assumed, accelerometer errors are insignificant as compared to other error sources.

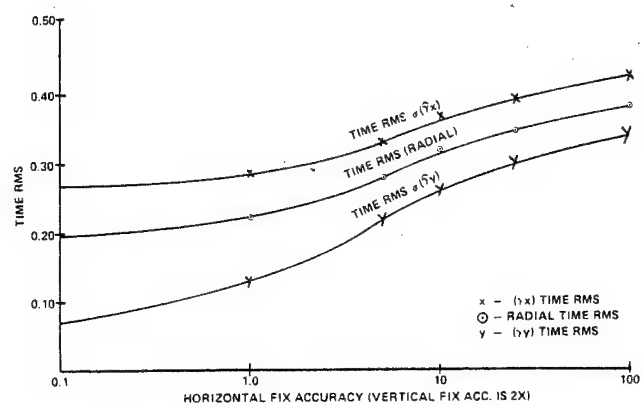


FIGURE 3 – TIME RMS VERTICAL DEFLECTION ESTIMATION ACCURACY VERSUS FIX ACCURACY

(U) In a similar fashion gyro errors were doubled and halved. (This was accomplished by quadrupling and quartering their P(0) and q). These results are plotted in figure 4. The large effect on vertical deflection estimation errors indicate that gyro drifts are a principal source of error. Any improvement in gyro performance will effect a not too far from proportionate change in vertical deflection estimation accuracy.

The standard deviation of modeled vertical deflection was doubled and halved. The results plotted in figure 5 inidicate that if vertical deflection changes are known to be smaller the knowledge could be used to effect somewhat improved accuracy.

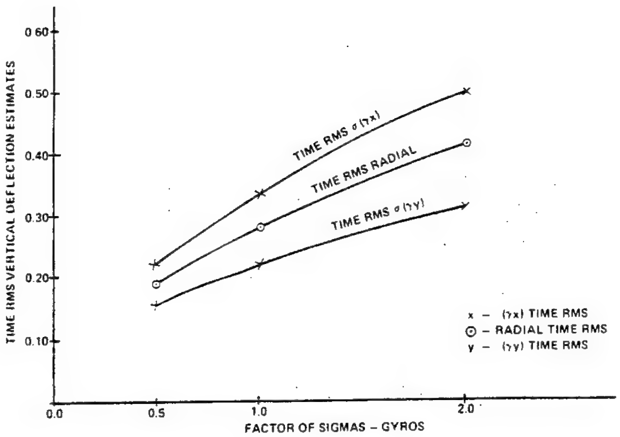


FIGURE 4– TIME RMS VERSUS FACTOR ON GYRO ERRORS

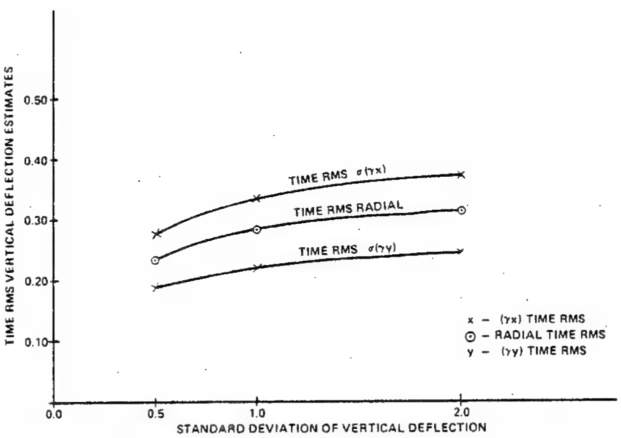


FIGURE 5 – THE EFFECT OF δ OF MODELED VERTICAL DEFLECTIONS

However, an almost nonexistent effect of varying modeled vertical deflection correlation distance was observed. These results suggest that accuracy of vertical deflection estimation will not be too sensitive to choice of model parameters. A small reduction in error with ship speed suggested that increased survey vehicle speed is desirable.

Figure 6 shows the effect of varying the duration of the run from 2 through 24 hours. The increased error with run duration is most attributable to gyro errors increasing with time. The effects of these errors on position are difficult to differentiate from those caused by vertical deflection.

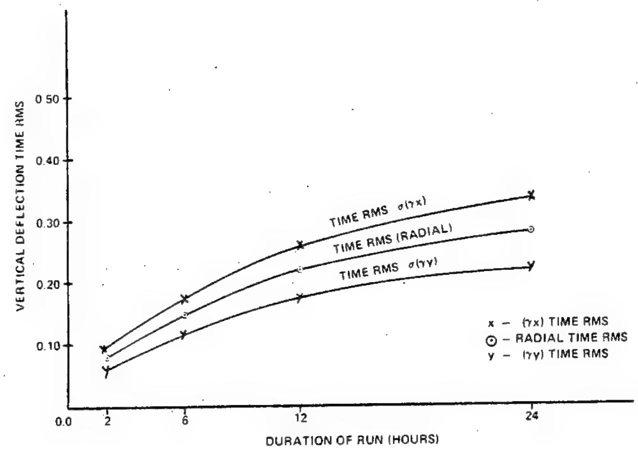


FIGURE 6 – THE EFFECT OF RUN DURATION

FUTURE PLANNING

(U) This effort has developed a basic formulation for Astro-Geodetic vertical deflection measurement. A smoothing computer program was developed for estimating vertical deflection from GPS and advance INS data. This program has been exercised to obtain predictions as to the effect of various parameter variation on the accuracy of vertical deflection surveys. The results have established the feasibility of this Astro-Geodetic technique and have identified the key areas of sensitivity to measurement error sources. It is planned to verify these predictions through repeated exercise of the Monte Carlo feature and comparison of the covariance values. Further work is planned in support of proposed testing with real shipboard survey data.

It is also planned to refine the technique increasing its efficiency and widening its applicability. Future efforts may consider airborne survey vehicles in addition to the shipboard vehicles currently being studied.

ASW RADAR NONCOOPERATIVE TARGET RECOGNITION

Task No. F61112001
IED Work Unit No. GC223

By D. Becker

Techniques are being developed for the classification or identification of ship targets, based on ship dimensions and physical features extracted from their radar returns. A three-class capability has been demonstrated, and efforts are underway to extend the techniques for demonstration of a six-class, aspect independent capability.

BACKGROUND

Long-range independent ASW radar target classification remains to be demonstrated. Early A-scope observations of AN/APS-116 radar high-resolution, range-amplitude returns disclosed valuable classification potential. Radar operators could differentiate between target classes. The range resolution cells for this radar are much smaller than the range extent of the target. Since the radar return is the convolution of the transmitted waveform and the reflectivity characteristics of the target, it should be possible to extract the physical dimensions of the target from the radar return. Predominant target structures will produce target signatures unique to targets under observation. Most approaches to the classification problem have relied primarily on analysis of range/amplitude profile shapes. Classification schemes have not used known physical parameters such as target length, width, distance between major scatterers, etc. Determining the classification potential of this approach has not been scientifically established.

OBJECTIVES

The objective of this IED program is to develop techniques for identifying or classifying ships at operational ranges by using physical details and dimensions extracted from radar return signals. The development includes the following tasks: (1) determine target physical features that can be extracted from a radar return signal. This is accomplished by applying various processing techniques to actual radar return data, (2) determine which target physical features can be used to identify or separate targets into classes. This is accomplished by applying techniques, such as cluster analysis, to target dimensions and features obtained from published target descriptions, drawings, etc, and (3) develop real time, aspect independent classification capabilities, using feature extraction methods developed in (1) for the features resulting from (2).

PROGRESS

Successful demonstration of a three-class identification capability has been accomplished. The target feature extraction and cluster analysis methods have been refined and can now be used as inputs for a six-class, aspect independent identification demonstration. Efforts are underway to develop a real time, on-line method for target feature extraction from the radar return signal.

Extraction Of Target Dimensions And Physical Features From Radar Returns

A range profile of a ship consists of the radar return amplitudes within a specified range window containing the ship. The range profile is obtained by envelope detecting the noncoherent high-resolution radar return signal. A digitized form of the range profile is then obtained by sampling the amplitude values within the range window. The radar used to gather the data was an airborne AN/APS-116 radar.

In addition to returns from different parts of a ship, a range profile also contains returns from sea clutter, which corrupt the ship information. Small ship motion (roll, pitch,

yaw) and changes in aspect angle of the ship direction in relation to the antenna boresight also cause changes in the range profile. Physical features that are extracted from the signal must be chosen which are aspect independent, and processing techniques must reduce the effects of clutter and target scintillation.

Classification Demonstration

A successful three-class demonstration has shown that gross dimensions and physical features can be extracted from a range profile and used to separate ship classes represented by the data. Data used in the demonstration consisted of range profiles for an aircraft carrier, destroyer, and a commercial freighter. One aspect angle was used. Features that were extracted from the data were target length and number of major radar scattering centers. To reduce the effects of clutter and target scintillation, features were extracted from averaged profiles. In this case seven successive profiles were averaged. (Each profile represents the return from one transmitted pulse, and successive profiles are separated by 0.1 second - successive pulses differ markedly, since those recorded are actually hundreds of pulse intervals apart. This separation was due to limitations in the data recording equipment.) A filtering operation was then applied to the averaged profile to determine the locations of major scatterers on the target. A threshold was then applied to the resulting data to choose scatterers and determine length. The two features were then fed to a classifier which made a classification decision.

Determination Of Best Features For Classification

In addition to determining which target attributes can be extracted from a radar signal, a determination must be made of which of these attributes will enable target class separation. This determination is not too difficult when dealing with one or two features. As the number of features increases, the task becomes increasingly more complex. A processing algorithm has been developed which examines sets of features to determine how well they can separate target data into target classes. This method is called cluster analysis, and the latest version, completed this year, can be used with any set of features. It will be applied to target dimensions and other target attributes to determine their usefulness as ship class separation features.

FUTURE PLANNING

A six-class demonstration is being developed to show a larger capability for classification, which will also be aspect angle independent. To have aspect angle independence, target features must be chosen that remain relatively constant over a wide range of aspect angles. Examples of possible features are ratios of amplitudes of major scatterer returns and ratios of distances between major scatterers. Feature extraction will be aided by an improved filtering algorithm that has been developed. Also planned is the development of a real time digital filter than can extract important ship features from the radar signal, without the need to store data after it has been sampled. This will reduce the amount of intermediate steps in the feature extraction process.

DEVELOPMENT OF DISTRIBUTED PROCESSING SYSTEM GENERATOR PROGRAM

Task No. F61113001
IED Work Unit No. GC225

By C. S. Czaplicki and F. C. Prindle

(U) The development of a global system generator for the Advanced Distributed Executive for the AN/AYK-14 (ADEX-14) is being investigated.

BACKGROUND

Distributed computer configurations have been projected as the next generation architecture for various avionics platforms. Current plans for such platforms as P-3, Light Airborne Multi-Purpose System (LAMPS), S-3A, Advanced Integrated Display System (AIDS), V/STOL and Basic Avionics Subsystems Integration Concept (BASIC) include some type of parallel processing. The advantages associated with a multiple processor architecture as compared to a single central processor are numerous. One is an increase in processing capability. Another is greater reliability and processor availability. The system can be designed to gracefully degrade upon processor failure. Another advantage is that with proper design, the processing capabilities of the avionic system can be expanded by incorporating additional processors when the processing requirements increase. As a result, the Advanced Distributed Executive for the AN/AYK-14 (ADEX-14) has been produced.

The system generation software provided today only accommodates one loadable processor. The design of a system generation program to provide loadable applications and executive programs across various platform configurations using the ADEX-14 can offer significant advantages to the avionics software implementation.

OBJECTIVES

The objective of this work unit is to explore and develop new approaches for a system generator which would provide coordinated loadable software for the ADEX-14 system on all of the loadable devices within the configuration. The goal is to provide variable load configuration capability for the software systems architect which would provide both flexibility and ease of use.

PROGRESS

Currently available system generators have been reviewed and new approaches to expand their capability for more than one processor have been investigated. Items investigated have been configuration management, loader interfaces and multi-computer loader directives. A multi-computer loader directive language has been formulated to support the Global Generation (GLOGEN) for the Advanced Distributed Executive for the AN/AYK-14 (ADEX-14).

A distributed processing system with several programmable devices under control of a Global Executive, requires a Global System Generator to allocate user tasks among these devices, to determine data flow requirements between these devices, and, more generally, to provide the Global Executive sufficient information about the overall distributed processing system so that executive services may be provided to the user in an orderly, configuration independent manner. A distributed processing system under the ADEX-14 Executive is such a system and GLOGEN fulfills this requirement. GLOGEN permits a user to adapt an application software system requesting ADEX-14 services, to any particular distributed processing configuration without the need to change source code or recompile. This is accomplished through a series of Global System generation steps, the end product of which is an executable memory load image for each AN/AYK-14

processor. This process is diagrammed in figure 1.

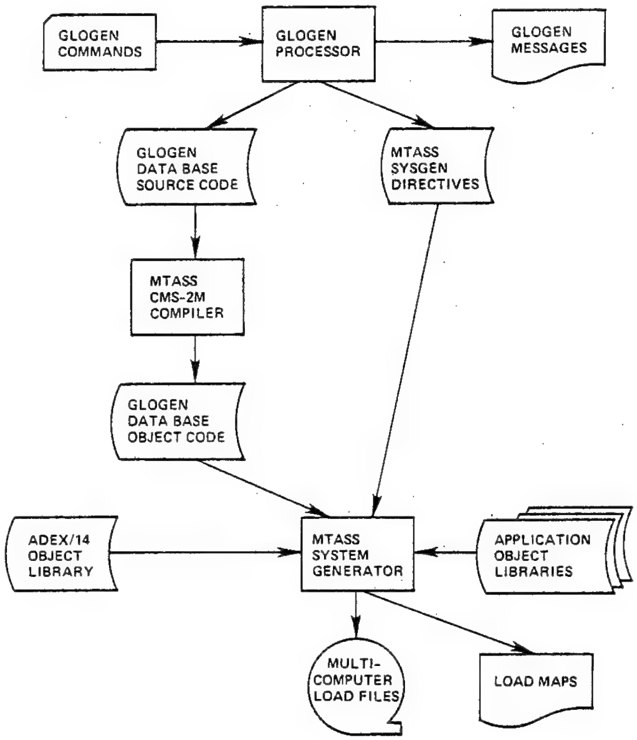


FIGURE 1 – GLOBAL SYSTEM GENERATION STEPS

The GLOGEN processor itself is the key element in this process; although SYSGEN and ADEX-14 have complex data requirements, the user specifies the relationship between his software and the distributed configuration in the simple and concise GLOGEN command language. This, coupled with the single FASP command invocation of the Global System generation process, greatly reduces the probability that errors will be introduced into the application system at system generation time.

FUTURE PLANNING

A "Global System Generator for the ADEX-14 (GLOGEN) Specification" will be written and published. The GLOGEN processor will be designed, coded and tested to support the AN/AYK-14 distributed processing configuration in the BASIC Laboratory.

SECTION II

INDEPENDENT RESEARCH WORK UNITS ACTIVE FOR FISCAL YEAR 1979

INDEPENDENT RESEARCH WORK UNITS ACTIVE FOR FISCAL YEAR 1979

(TELEPHONE 215-441-XXXX; AUTOVON 441-XXXX)

WORK UNIT/ TASK AREA NO.	DESCRIPTIVE TITLE	PRINCIPAL INVESTIGATOR NAME (CODE) TEL. EXT.	FY-1979 FUND LEVEL ($000)	DDC ACCESSION NO.
GC102/R01107	Solid-State Laser For Hydrography And Communications	G. Ferguson (3012) X3284	40.0	DN081033
GC103/R01403	Software Requirements Engineering Tools	W. Pohle (5023) X2462	25.0	DN081134
GC104/R01108	Processing Technique For Enhancement Of Acoustic Signals From Ocean Bottom Loss Measurement	T. Gabrielson (3032) X2171	26.0	DN081003
GC105/R02208	Research On Multi-Purpose Corrosion Inhibitors For Aerospace Materials In Naval Environments	V. Agarwala (6062) X2811	40.4	DN081284
GC106/R02101	Application Investigation For VHSIC	W. Hicklin (3032) X2142	70.0	DN081007
GC107/R04106	DFS-System Integration Development Plan	R. Crosbie (6004) X2188	25.0	DN081195
GC108/R01408	Application Of CCD Correlators To JTIDS Signal Processing	Y. Lui (4042) X2612	33.0	DN081053
GC146/ZR01107	Metal Vapor Laser Investigation	G. Ferguson (3012) X3284	105.0	DN581047
GC153/ZR02208	Research On Catastrophic Damage Phenomena And Damage Control In Naval Aircraft Alloys	J. De Luccia (6062) X2824	20.0	DN781418
GC161/ZR01407	Gas Bubble Chaff Investigation	W. Hicklin (3023) X2142	60.0	DN781255
GC177/ZR02206	Research On Polyvinylidene Fluoride Transducers For Non-Destructive Testing Applications	W. Scott (6063) X3232	30.0	DN881177

INDEPENDENT RESEARCH WORK UNITS ACTIVE FOR FISCAL YEAR 1979

WORK UNIT/ TASK AREA NO.	DESCRIPTIVE TITLE	PRINCIPAL INVESTIGATOR NAME (CODE) TEL. EXT.	FUND LEVEL ($000)	DDC ACCESSION NO.
GC178/ZR02206	Surface Reinforcement Of Gas Turbine Components By Refractory Coatings Deposited By Means Of Vacuum Pyrolysis	J. De Luccia (6062) X2824	48.0	DN881212
GC180/ZR01403	Development Of Advanced Airborne Executive Program	W. Pohle (5032) X2462	100.0	DN881066
GC182/ZR04106	Repeated Acceleration Exposure Effects	E. Hendler (6003) X2196	80.0	DN881086
GC185/ZR04106	Timing Of G-Protective Techniques	M. Cohen (6003) X3253	47.8	DN881475
GC186/ZR04106	In-Vitro And In-Vivo Immuno Chemistry of PGB_X	H. Shmukler (6022) X2736	55.0	DN881508
GC187/ZR04106	Room Temperature Supercondition In Organic Solids And Biological Systems	F. Cope (6022) X2733	55.0	DN881427
GC188/ZR02206	Radar Transparent Rigid Polyurethane Polymer And Composites For Radomes	H. Lee (60161) X2575	71.5	DN881429
GC189/ZR01111	Systematic Investigation Of Potential Non-Acoustic Submarine Detection Techniques	P. Moser (3010) X2305	102.3	DN881677
GC190/ZR04106	Effects Of Low-Intensity Laser Pulses On Visual-Motor Performance	A. Salzberg (6021) X2730	10.0	DN881474
GC191/ZR02101	MM Wave Investigation For Electronic Warfare	D. Davis (3023) X2514	56.0	DN881654

INDEPENDENT RESEARCH WORK UNITS ACTIVE FOR FISCAL YEAR 1979 (CON'T)

WORK UNIT/ TASK AREA NO.	DESCRIPTIVE TITLE	PRINCIPAL INVESTIGATOR NAME (CODE) TEL. EXT.	FY-1979 FUND LEVEL ($000)	DDC ACCESSION NO.
GC193/ZR01405	Coherent Radar Sea Clutter Measurements	R. Gallis (3022) X2301	250.0	DN881655
GC194/ZR01407	Astro-Geodetic Measurement Of Vertical Deflection With GPS And Advanced INS	L. Chin (4012) X2674	40.0	DN881606
GC196/ZR01407	Low-Cost Air Vehicle Parameter Data Acquisition System	J. Licht (3034) X3070	35.0	DN981196
GC197/ZR01411	System Technology Program	J. Guarini (20P5) X3172	180.00	DN981195

THIS PAGE LEFT BLANK INTENTIONALLY

SECTION III

INDEPENDENT EXPLORATORY DEVELOPMENT WORK UNITS ACTIVE FOR FISCAL YEAR 1979

INDEPENDENT EXPLORATORY DEVELOPMENT WORK UNITS ACTIVE FOR FISCAL YEAR 1979

(TELEPHONE 215-441-XXXX; AUTOVON 441-XXXX)

WORK UNIT/ TASK AREA NO.	DESCRIPTIVE TITLE	PRINCIPAL INVESTIGATOR NAME (CODE) TEL. EXT.	FY-1979 FUND LEVEL ($000)	DDC ACCESSION NO.
GC217/F61112001	Active Sonar Automatic Classification	G. Marshall (3042) X2181	5.0	DN781201
GC219/F61112001	Submarine Target Depth Determination	M. Mele (3041) X2126	60.0	DN881163
GC221/F61112001	Airborne Infrared Search And Track Set Performance Modeling	G. Shamlian (3011) X2580	39.0	DN881675
GC222/F61112001	Quadrature Correlative Vertical Line Array Processing Techniques	W. Richardson (3044) X2130	75.0	DN981106
GC223/F61112001	ASW Radar Noncooperative Target Recognition	D. Becker (3022) X2688	83.0	DN781248
GC224/F61112001	Solid-State Laser Display Device	W. McMillen (5023) X2069	39.0	DN081117
GC225/F61113001	Development Of Distributed Processing System Generator Program	W. Pohle (5032) X2462	25.0	DN881066
GC333/F61412001	Investigation Of Software Mean Time Between Failures	R. Pariseau (5033) X3145	128.0	DN781354
GC335/F61412001	CV-TSC Integrated Strike Support Center	D. Tauras (2012) X2154	142.0	DN881426
GC336/F61412001	Preliminary Airborne Testing Of A G-Protective Supine Seat System	J. Harding (6030) X2503	16.0	DN881678
GC337/F61412001	Development Of New Centrifuge Control Algorithms	R. Crosbie (6004) X2188	58.0	DN081187
HL505/F61212001	Remotely Activated And Controlled Torpedo	R. Houser (3042) X2584	100.0	DN881472

THIS PAGE LEFT BLANK INTENTIONALLY

SECTION IV

COMPLETED OR TERMINATED WORK UNITS
FOR FISCAL YEAR 1979

INDEPENDENT RESEARCH

COMPLETED OR TERMINATED WORK UNITS FOR FISCAL YEAR 1979

INDEPENDENT RESEARCH

WORK UNIT/ TASK AREA NO.	DESCRIPTIVE TITLE	REASON FOR DISCONTINUANCE
GC107/R01408	DFS-System Integration Development Plan	Completed
GC108/R01408	Application Of CCD Correlators To JTIDS Signal Processing	Terminated
GC146/ZR01107	Metal Vapor Laser Investigation	Completed
GC153/ZR02208	Research On Catastrophic Damage Phenomena And Damage Control In Naval Aircraft Alloys	Terminated
GC161/ZR01407	Gas Bubble Chaff Investigation	Terminated
GC177/ZR02206	Research On Polyvinylidene Fluoride Transducers For Non-Destructive Testing Applications	Terminated
GC186/ZR04106	In-Vitro And In-Vivo Immuno Chemistry Of PGB_X	Terminated
GC189/ZR01111	Systematic Investigation Of Potential Non-Acoustic Submarine Techniques	Completed
GC190/ZR04106	Effects Of Low-Intensity Laser Pulses On Visual-Motor Performance	Terminated
GC196/ZR01407	Low-Cost Air Vehicle Parameter Data Acquisition System	Completed

THIS PAGE LEFT BLANK INTENTIONALLY

SECTION V

COMPLETED OR TERMINATED WORK UNITS FOR FISCAL YEAR 1979

INDEPENDENT EXPLORATORY DEVELOPMENT

COMPLETED OR TERMINATED WORK UNITS FOR FISCAL YEAR 1979

INDEPENDENT EXPLORATORY DEVELOPMENT

WORK UNIT/ TASK AREA NO.	DESCRIPTIVE TITLE	REASON FOR DISCONTINUANCE
GC217/F61112001	Active Sonar Automatic Classification	Completed
GC219/F61112001	Submarine Target Depth Determination	Completed
GC222/F61112001	Quadrature Corrective Vertical Line Array Processing Techniques	Completed
GC224/F61112001	Solid-State Laser Display Device	Terminated
GC333/F61412001	Investigation Of Software Mean Time Between Failures	Terminated
GC335/F61412001	CV-TSC Integrated Strike Support Center	Completed
GC336/F61412001	Preliminary Airborne Testing Of A G-Protective Supine Seat System	Completed
HL505/F61212001	Remotely Activated And Controlled Torpedo	Completed

THIS PAGE LEFT BLANK INTENTIONALLY

SECTION VI

INDEPENDENT RESEARCH WORK UNITS ACTIVE FOR FISCAL YEAR 1980

INDEPENDENT RESEARCH WORK UNITS ACTIVE FOR FISCAL YEAR 1980

(TELEPHONE 215-441-XXXX; AUTOVON 441-XXXX)

WORK UNIT/ TASK AREA NO.	DESCRIPTIVE TITLE	PRINCIPAL INVESTIGATOR NAME (CODE) TEL. EXT.	FY-1980 FUND LEVEL ($000)	DDC ACCESSION NO.
GC102/ZR01107	Solid-State Lasers For Hydrography And Communications	G. Ferguson (3012) X3284	64.0	DN081033
GC103/ZR01403	Software Requirements Engineering Tools	M. Plotkin (5033) X2462	55.0	DN08134
GC104/ZR001108	Processing Technique For Enhancement Of Acoustic Signals From Ocean Bottom Loss Measurement	T. Gabrielson (3032) X2172	29.7	DN081003
GC105/Z02208	Research On Multi-Purpose Corrosion Inhibitors For Aerospace Materials In Naval Environments	V. Agarwala (6062) X2811	85.0	DN081282
GC106/ZR02101	Application Investigation For VHSIC	W. Hicklin (3023) X2142	93.0	DN081007
GC109/ZR023024	Jet/Aerodynamic Surface Interface Model For V/STOL Aircraft	K. Yen (6053) X2221	83.1	DN081480
GC110/ZR01112	Development Of An Improved Image Quality Summary Measure	S. Campana (3011) X2942	108.0	DN081345
GC111/ZR01407	Algorithm Development For Optimal Search Tactics With ASW Sensors	D. Birnbaum (2031) X3096	85.0	DN081327
GC/112/ZR01107	Rare-Earth Vapor Phase Laser Investigation	G. Ferguson (3012) X3284	98.0	DN081334
GC113/ZR01107	Green Lasers For Airborne Hydrography	G. Ferguson (3012) X3284	125.0	DN881212
GC178/ZR02206	Surface Reinforcement Of Gas Turbine Components By Refractor Coatings Deposited By Means Of Vacuum Pyrolysis	S. Brown (6062) X2824	48.0	DN881212

INDEPENDENT RESEARCH WORK UNITS ACTIVE FOR FISCAL YEAR 1980 (CON'T)

WORK UNIT/ TASK AREA NO.	DESCRIPTIVE TITLE	PRINCIPAL INVESTIGATOR NAME (CODE) TEL. EXT.	FY-1980 FUND LEVEL ($000)	DDC ACCESSION NO.
GC180/ZR01403	Development Of Advanced Airborne Executive Program	W. Pohle (5032) X2462	165.3	DN881066
GC182/ZR04106	Repeated Acceleration Exposure Effects	E. Hendler (6003) X2196	139.0	DN881086
GC185/ZR04106	Timing of G-Protective Techniques	M. Cohen (6003) X3253	53.5	DN881475
GC187/ZR04106	Room Temperature Superconduction In Organic Solids And Biological Systems	F. Cope (6003) X2733	87.0	DN881427
GC188/ZR02206	Radar Transparent Rigid Polyurethane Polymer And Composites For Radomes	H. Lee (6061) X2475	67.0	DN881429
GC191/ZR02101	MM Wave Investigation For Electronic Warfare	W. Hicklin (3043) X2142	35.0	DN881654
GC193/ZR01405	Coherent Radar Sea Clutter Measurements	R. Gallis (3022) X2301	65.0	DN881655
GC194/ZR01407	Astro-Geodetic Measurement Of Vertical Deflection With GPS And Advanced INS	J. Calabria (4012) X2583	90.0	DN881606
GC197/ZR01411	Systems Technology Program	J. Guarini (20P5) X3172	120.00	DN981195

SECTION VII

INDEPENDENT EXPLORATORY DEVELOPMENT WORK UNITS ACTIVE FOR FISCAL YEAR 1980

INDEPENDENT EXPLORATORY DEVELOPMENT WORK UNITS ACTIVE FOR FISCAL YEAR 1980

(TELEPHONE 215-441-XXXX; AUTOVON 441-XXXX)

WORK UNIT/ TASK AREA NO.	DESCRIPTIVE TITLE	PRINCIPAL INVESTIGATOR NAME (CODE) TEL. EXT.	FY-1980 FUND LEVEL ($000)	DDC ACCESSION NO.
GC221/ZF66112001	Airborne Infrared Search & Track Set (AIRST) Performance Modeling	G. Shamlian (3011) X2283	62.0	DN881675
GC223/ZF66112001	ASW Radar Noncooperative Target Recognition Using Target Physical Details And Dimensions	D. Becker (3022) X2688	45.0	DN781248
GC225/ZF66112001	Development Of Distributed Processing System Generator Program	C. Czaplicki (5032) X3145	150.0	DN081147
GC226/ZF66112001	ECCM Techniques For Air-To-Surface Tactical Radars	G. Catrambone (3024) X2688	85.0	DN081337
GC227/ZF66112001	Sonar Detection Of Aircraft Sources	J. Dale (3043) X2135	60.0	DN081331
GC228/ZF66112001	Sensor/Processor DC&T Range Study	R. Marshall (3034) X2815	72.0	DN081355
GC337/ZF66412001	Development Of New Centrifuge Control Algorithms	R. Crosbie (6004) X2189	62.0	DN081187
GC338/ZF66112001	Microprocessor Software Development System	H. Stuebing (503) X2314	144.4	DN081420
GC339/ZF66412001	Software Life-Cycle Information Aids	M. Plotkin (5033) X3145	78.0	DN081421
GC340/ZF66112001	Cost Estimating Methodology Research	A. Burstein (2023) X2160	125.0	DN181022

THIS PAGE LEFT BLANK INTENTIONALLY

SECTION VIII

INDEPENDENT RESEARCH AND INDEPENDENT EXPLORATORY DEVELOPMENT RELATED PUBLICATIONS DURING FISCAL YEAR 1979

INDEPENDENT RESEARCH AND INDEPENDENT EXPLORATORY DEVELOPMENT RELATED PUBLICATIONS DURING FISCAL YEAR 1979

AUTHOR(s): G. Ferguson

TITLE: Specification Of Patent Application For "Laser Device With Intraresonator Harmonic Generation"

PURPOSE: Publication In The "National Technical Information Service, Department Of Commerce"

AUTHOR(s): H. Stuebing

TITLE: "Facility For Automated Software Production (FASP)"

PURPOSE: Publication In The Proceedings Of The ACM 1978 Conference

AUTHOR(s): F. Cope

TITLE: "Pulsed Nuclear Magnetic Resonance Of Potassium (^{39}K) Of Whole Body Live And Dead Mice. Double Oscillation Frequencies In T_1 Decay Curves"

PURPOSE: Publication In "Physiological Chemistry And Physics"

AUTHOR(s): F. Cope

TITLE: "Delocalized Clouds (Wave Functions) Of Polymerized Tachyon Magnetoelectric Monopoles – A Possible Cause Of Large Periodic (In Space) Auras Around Solids And Liquids, Detected By Sensitive Persons (Dowsers)"

PURPOSE: Publication In "Physiological Chemistry And Physics"

AUTHOR(s): F. Cope

TITLE: "Man In Gas Of Tachyon Magnetoelectric Dipoles – A New Hypothesis. Part IV. Beta Rays May Add To Magnetoelectric Dipoles In Accord with Schwinger Condition To Yield Toxic Products Observed In Reich Oranur Experiment. A Possible Mechanism For Toxic Air Ion Effects"

PURPOSE: Publication In "Physiological Chemistry And Physics"

AUTHOR(s): M. Cohen

TITLE: "Effects Of Sweeping Linear Accelerations On The Perceived Locations Of Visual Targets: Psychophysical Measures"

PURPOSE: Publication In The Proceedings Of The 50th Annual Scientific Meeting Of The Aerospace Medical Association

AUTHOR(s): L. Chin

TITLE: "A Method Of Optimizing The Update Intervals In Hybrid Navigation Systems"

PURPOSE: Publication In The "American Institute Of Aeronautics And Astronautics"

AUTHOR(s): H. Schmukler

TITLE: The High-Performance Molecular Exclusion Chromatography Of PGB_X"

PURPOSE: General Distribution

AUTHOR(s): W. Scott

TITLE: "NDI Methods For Composite Materials"

PURPOSE: Publication In The Proceedings Of The ASTM Conference On Nondestructive Evaluation And Flaw Criticality For Composite Materials

AUTHOR(s): H. Schmukler

TITLE: "Urinary Molecular Determinants For The Prediction Of Ischemic Anoxic Stress Pathology: Evaluation Of Lipid Peroxides, Phenolic Acids And Generated Free Radical Compounds As Bioindicators Of Stress"

PURPOSE: General Distribution

AUTHOR(s): F. Cope

TITLE: "Avarami Analysis Of Electrical Switching In Hydrated Melanin Suggests Dependence On A Phase Transition"

PURPOSE: Publication In "Physiological Chemistry And Physics"

AUTHOR(s): F. Cope

TITLE: "Magnetoelectric Charge States Of Matter-Energy. A Second Approximation. Part I. A Test Of The Magnetoelectric Dipole Structure Hypothesis For Electrons, Neutrons, And Protons. Estimation Of High Mass For The Single Magnetoelectric Dipole, Leading To A Possible Role In Biological And Physical Cosmic Observations"

PURPOSE: Publication In "Physiological Chemistry And Physics"

AUTHOR(s): F. Cope

TITLE: "Magnetoelectric Charge States Of Matter-Energy. A Second Approximation. Part II. Magnetoelectrets As Possible Evidence Of Magnetoelectric Dipoles In Solids, And As A Possible Mechanism For Biological Effects Of Magnetic Fields"

PURPOSE: Publication In "Physiological Chemistry And Physics"

AUTHOR(s):	Y. Lui
TITLE:	TIES Narrowband Signal Conversion Unit Design Report"
PURPOSE:	General Distribution
AUTHOR(s):	F. Cope
TITLE:	"Overvoltage And Solid-State Kinetics Of Reactions At Biological Interface. Cytochrome Oxidase. Photobiology, And Cation Transport. Therapy Of Heart Disease And Cancer"
PURPOSE:	Publication In The Proceedings Of The American-Australian Symposium On Bioelectrochemistry
AUTHOR(s):	H. Schmukler
TITLE:	"The Separation Of PGB_X Into Molecular Weight Classes By Dialysis"
PURPOSE:	General Distribution
AUTHOR(s):	H. Stuebing
TITLE:	"A Modern Facility For Software Production And Maintenance"
PURPOSE:	Publication In The Advisory Group For Aerospace Research And Development (HGARD) For The North Atlantic Treaty Organization
AUTHOR(s):	H. Schmukler
TITLE:	"Studies On PGB_X – Isolation Of A PGB_X With Reduced Inhibitor Content"
PURPOSE:	General Distribution
AUTHOR(s):	F. Cope
TITLE:	"Magnetoelectric Charge States Of Matter-Energy. A Second Approximation. Part III. Magnetoelectric Dipoles In Gases, And Liquids, Especially In Water. Evidence Suggesting Magnetoelectric Ionization And Magnetoelectrophoresis. The Ehrenhaft Experiements"
PURPOSE:	Publication In "Physiological Chemistry And Physics"
AUTHOR(s):	F. Cope
TITLE:	"Magnetoelectric Charge States Of Matter-Energy. A Second Approximation. Part IV. Delocalization Of Magnetoelectric Monopoles Predicted From Heisenberg Uncertainty Principle, As Is Facilitation Of Monopole Detection By Magnetic And Electric Fields"
PURPOSE:	Publication In "Physiological Chemistry And Physics"

AUTHOR(s): F. Cope

TITLE: "Proteins, Semiconduction, Charge Transfer Complexes, Cancer And Albert Szent-Gyorgyi"

PURPOSE: Publication In "Chemical And Engineering News"

AUTHOR(s): G. Ferguson

TITLE: "Underwater Target Designation"

PURPOSE: Publication In The Proceedings Of SPIE Ocean Optic VI Seminar

AUTHOR(s): M. Cohen

TITLE: "Visual-Proprioceptive Interactions"

PURPOSE: Publication In Book Entitled "Intersensory Perception And Sensory Integration"

AUTHOR(s): J. DeLuccia

TITLE: "Amlguard—A Corrosion Preventative Compound For Aerospace"

PURPOSE: Publication In "Metals Progress"

AUTHOR(s): E. Hendler

TITLE: "Summary Review Of The Influence Of Thermal Radiation On Human Skin"

PURPOSE: General Distribution

AUTHOR(s): E. Hendler

TITLE: "The Fractionation Of PGB_X By Molecular Exclusion Chromatography"

PURPOSE: General Distribution

SECTION IX

INDEPENDENT RESEARCH AND INDEPENDENT EXPLORATORY DEVELOPMENT RELATED PRESENTATIONS DURING FISCAL YEAR 1979

INDEPENDENT RESEARCH AND INDEPENDENT EXPLORATORY DEVELOPMENT RELATED PRESENTATIONS DURING FISCAL YEAR 1979

AUTHOR(s): H. Stuebing

TITLE: "Facility For Automated Software Production (FADP)"

PURPOSE: Presentation At The ACM 1978 Conference; Washington, DC - December 1978

AUTHOR(s): J. Harding

TITLE: "Test And Evaluation Process For Life Support Systems"

PURPOSE: Presentation At The 16th Annual SAFE Symposium; San Diego, CA - October 1978

AUTHOR(s): E. Hendler and D. Johanson

TITLE: "Some Human Responses To Repeated $+G_z$ Pulses"

PURPOSE: Presentation At The 35th Panel Business Meeting/Specialists' Meeting On The Aerospace Medical Panel Of AGARD; Avancees, France - November 1978

AUTHOR(s): M. Cohen

TITLE: "Timing Of G-Protective Techniques"

PURPOSE: Presentation To The Aerospace Medical Association; Anaheim, CA - May 1979

AUTHOR(s): E. Hendler

TITLE: "Performance During Exposure To Acceleration"

PURPOSE: Presentation To The Aerospace Medical Association; Anaheim, CA - May 1979

AUTHOR(s): V. Agaruala and J. DeLuccia

TITLE: "Effects Of Magnetic Field On Hydrogen Evolution Reaction And Its Diffusion In Iron And Steel"

PURPOSE: Presentation At The 7th International Congress On Metallic Corrosion - November 1978

AUTHOR(s): M. Cohen

TITLE: "Effects Of Sweeping Linear Accelerations On The Preceived Locations Of Visual Targets: Psycho-physical Measures"

PURPOSE: Presentation At The 50th Annual Scientific Meeting Of The Aerospace Medical Association; Washington, DC - March 1979

AUTHOR(s): R. Pariseau

TITLE: "A Screening Criterion For Delivered Source In Military Software"

PURPOSE: Presentation At The 4th International Conference On Software Engineering; Munich, Germany - September 1979

AUTHOR(s): J. DeLuccia

TITLE: "Environmentally Induced Catastrophic Damage Phenomena And Control"

PURPOSE: Presentation At The 1978 AFSC/NAVMAT Science And Engineering Symposium; San Diego, CA - October 1978

AUTHOR(s): E. Hendler

TITLE: "Some Human Responses To Repeated $+G_z$ Pulses"

PURPOSE: Presentation At The NATO/AGARD 35th Aerospace Medical Panel Meeting; Paris, France - November 1978

AUTHOR(s): W. Scott

TITLE: "On Interlaminar Defects In Laminated Composites"

PURPOSE: Presentation At The 12th Annual Symposium On Fracture Mechanics; St. Louis, MO - May 1979

AUTHOR(s): H. Steubing

TITLE: "Facility For Automated Software Production (FASP)"

PURPOSE: Presentation At The 4th International Conference On Software Engineering; Munich, Germany - September 1979